the OIL AND GAS JOURNAL

APRIL 30, 1956

Annual

EXPLORATION

Number

Finding Oil With Geophysics p. 123-A

The Geological Outlook p. 104

The Geophysical Outlook p. 110

The World's Giant Fields p. 113

Wildcat Drilling in 1955 p. 136

Plus

A Look at Some Leading U. S. Oil Provinces

From FIELD EXPERIENCE, ENGINEERING KNOWLEDGE, MANUFACTURING SKILL—

UNIT RIG has developed a new 1400 horsepower draw works — The U-914-A. If you have a requirement for 9000' - 14000' drilling, see this exceptional new draw works before you buy.

UNIT RIG & EQUIPMENT COMPANY / TULSA, OKLAHOMA

A Glance Ahead . . . . at press time

These trends will make TOMORROW'S NEWS

Look for steel prices to go up in a big way early this summer. Increase now being talked is $10 to $14 a ton. Expected date is the first week in July —just after labor contracts expire.

General expectation is that any labor problems will be settled promptly, with some increase in wages. Higher prices then will be blamed, in part, on higher costs. Needed expansion will be the rest of the reason given for higher prices. Steel has been saying that expansion is necessary and that money for this expansion must be raised through increased income from steel products.

Antibiotics for oil wells? A leading pharmaceutical house has had inquiries from a major oil-producing company for a large quantity of one of the "-mycins." The company is thought to be studying the possibility of using this bactericide to control the sulfate-reducing bacteria which are causing corrosion in oil wells and elsewhere.

Canadian refiners may soon have some new competition. British Petroleum is known to be surveying the possibilities of building in Ontario or Quebec, or both. An unnamed American oil company is negotiating for a 105-acre lease south of Sarnia, Ont., with the intention of adding a fourth refinery to that growing oil center.

Economists are revising upward their 1956 estimates of total U. S. oil demand. Reason is the 5¼ per cent gain in the first quarter, compared with the same period last year. The increase is at least 60,000 bbl. greater than was expected, and it largely accounts for the improved product markets in several areas.

The administration will shortly come up with some new rules on trade with Russia. The list of goods that can be shipped to the Soviets may be expanded. A more liberal policy on exchanges of visitors may be announced. Both could affect plans of Dresser Industries to acquire a new drill bit developed by the Communists.

Look for higher octane gasolines on the East Coast. Buyers on the Gulf Coast are hunting for the top octane grades. The normal cargo of regular gasoline sold on the Gulf Coast for shipment to the East Coast has been 90 octane. Current purchases and inquiries indicate that normal regular will be 92 octane this season. Premium will move up from 97 to 98 octane.

Atlantic Refining and Pure Oil are taking a new look at foreign operations—Pure for the first time.

Rawleigh Warner, Pure chairman, told stockholders Pure is expanding its exploratory effort in Canada and "other foreign areas." Atlantic's president, Henderson Supplee, Jr., made much the same comment. Atlantic has more than 750,000 acres under concession in Venezuela, but production last year dropped 4½ per cent to 19,700 bbl. daily. It also is doing exploratory work on 2,000,000 acres in Cuba.

the OIL AND GAS JOURNAL

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By A. I. Levorsen

A summary of things to be done in discovering the needed oil fields to supply the United States.

What Is the Geophysical Outlook? 110

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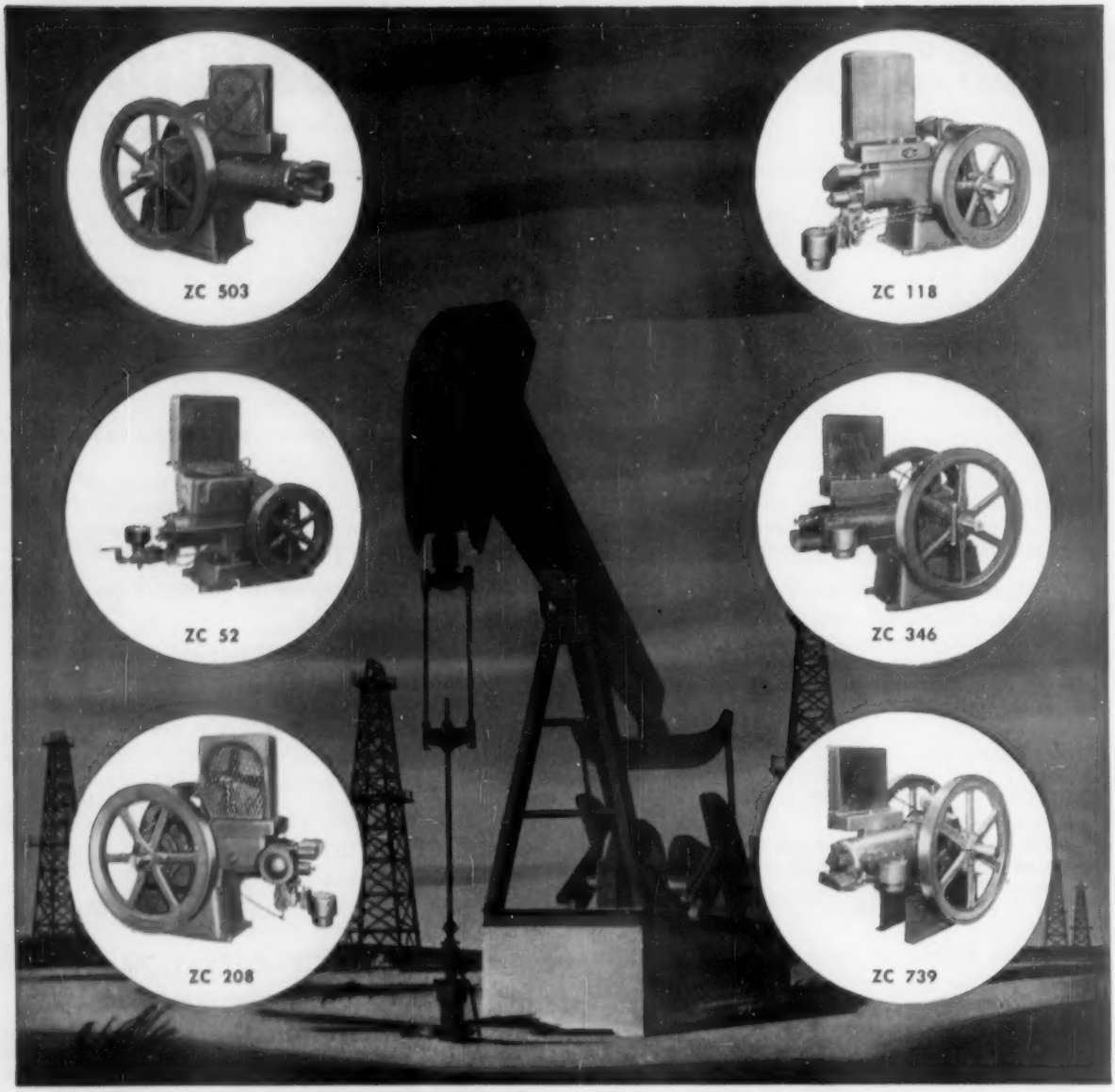

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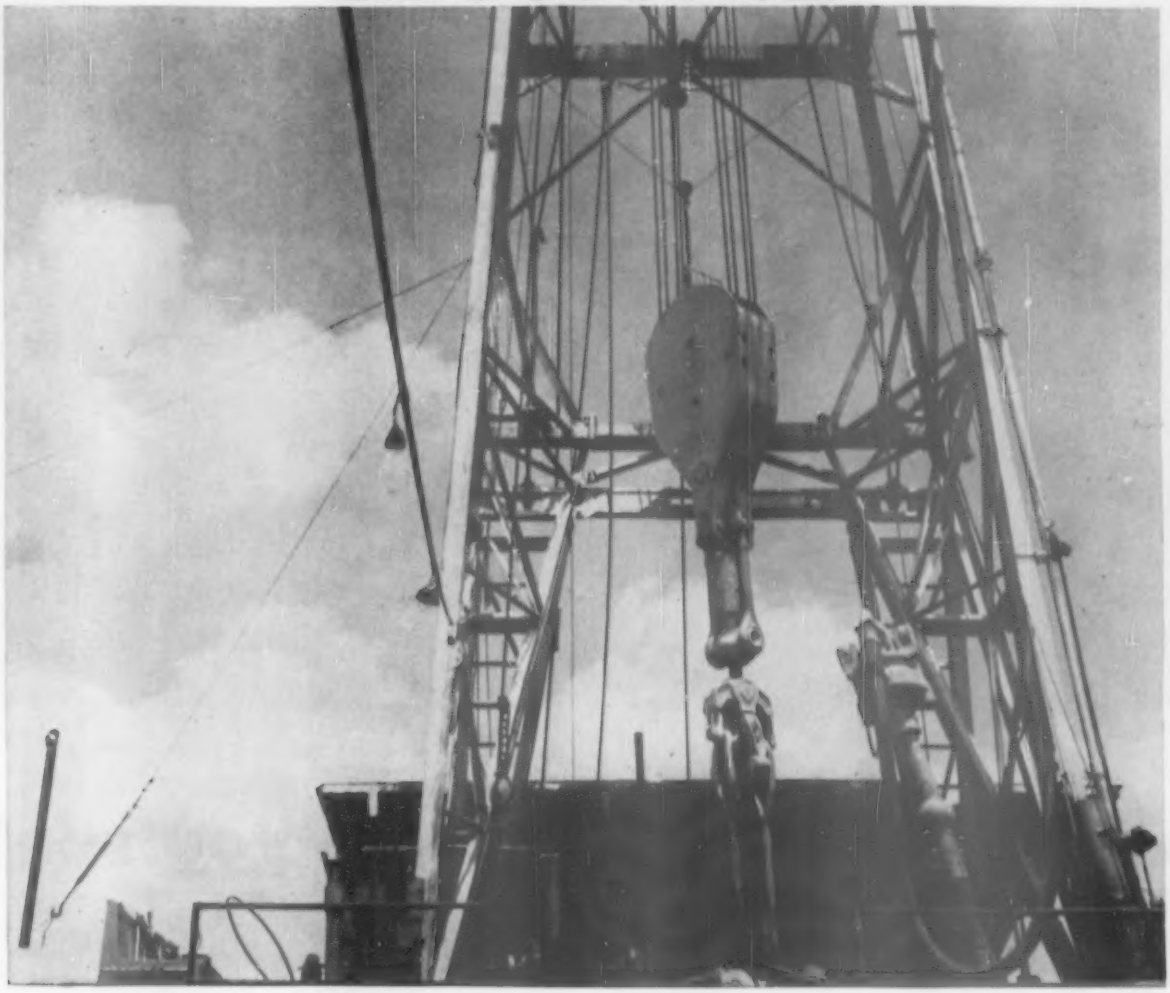

Stop costly hose blowouts with B. F. Goodrich rotary drilling hose

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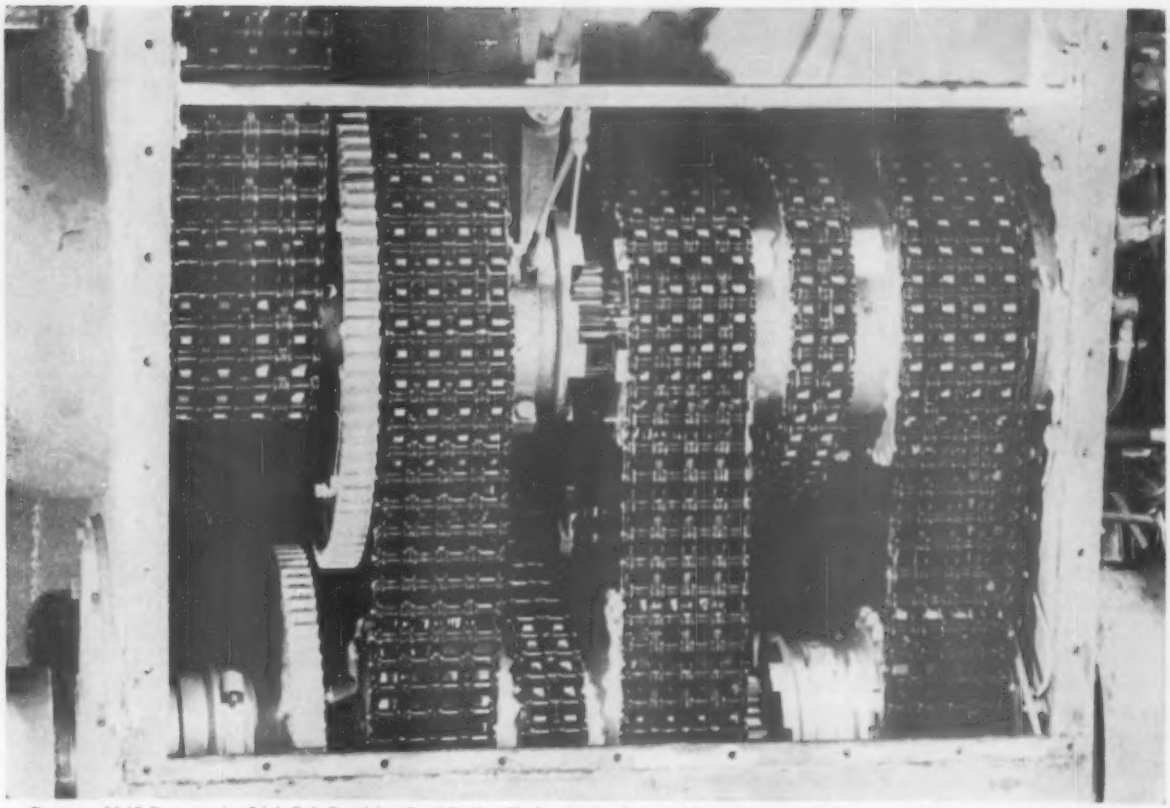

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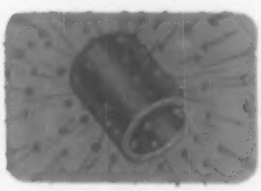

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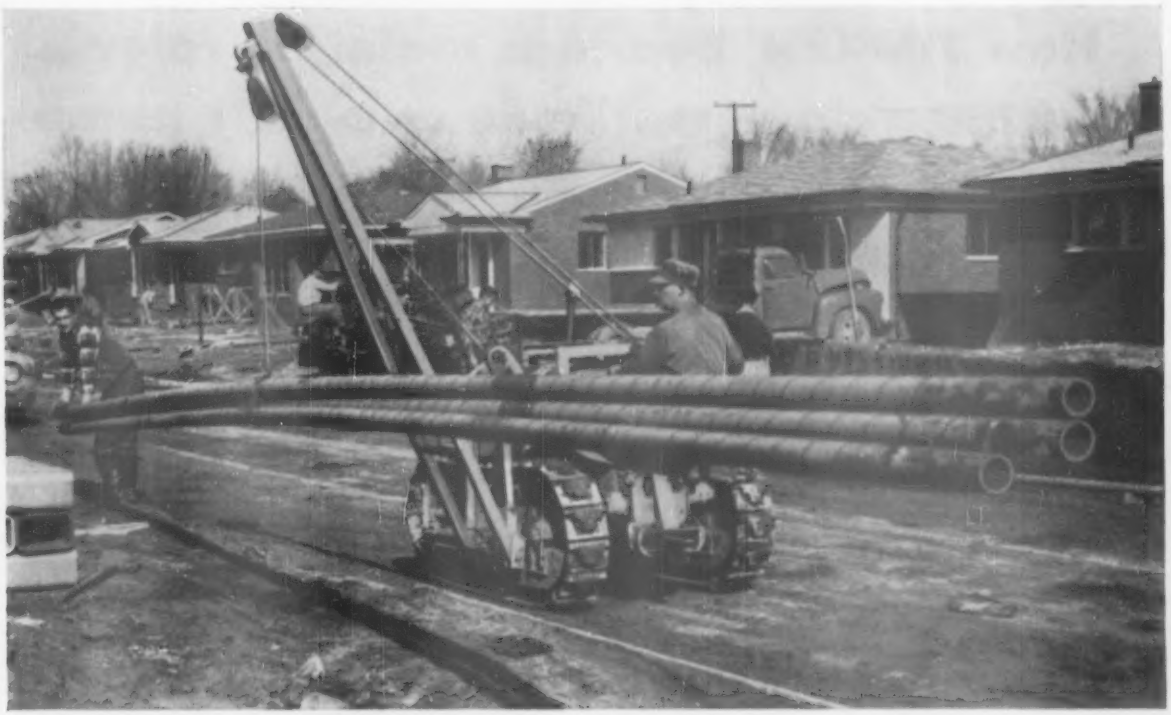
Cut-away shows where Monel and "K" Monel nickel-copper alloys are used to give this BT Pressure Recorder its reliable performance.

In a few hours this Halliburton Testing Specialist will have the complete Drill Stem Test pressure data of this well . . . drawn on a coated metal chart. The Pressure Recorder made with Monel nickel-copper alloy in his hand does the job.



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DITCH CLEANUP

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How TIMKEN® bearings maintain rotor adjustment in versatile, heavy-duty pump

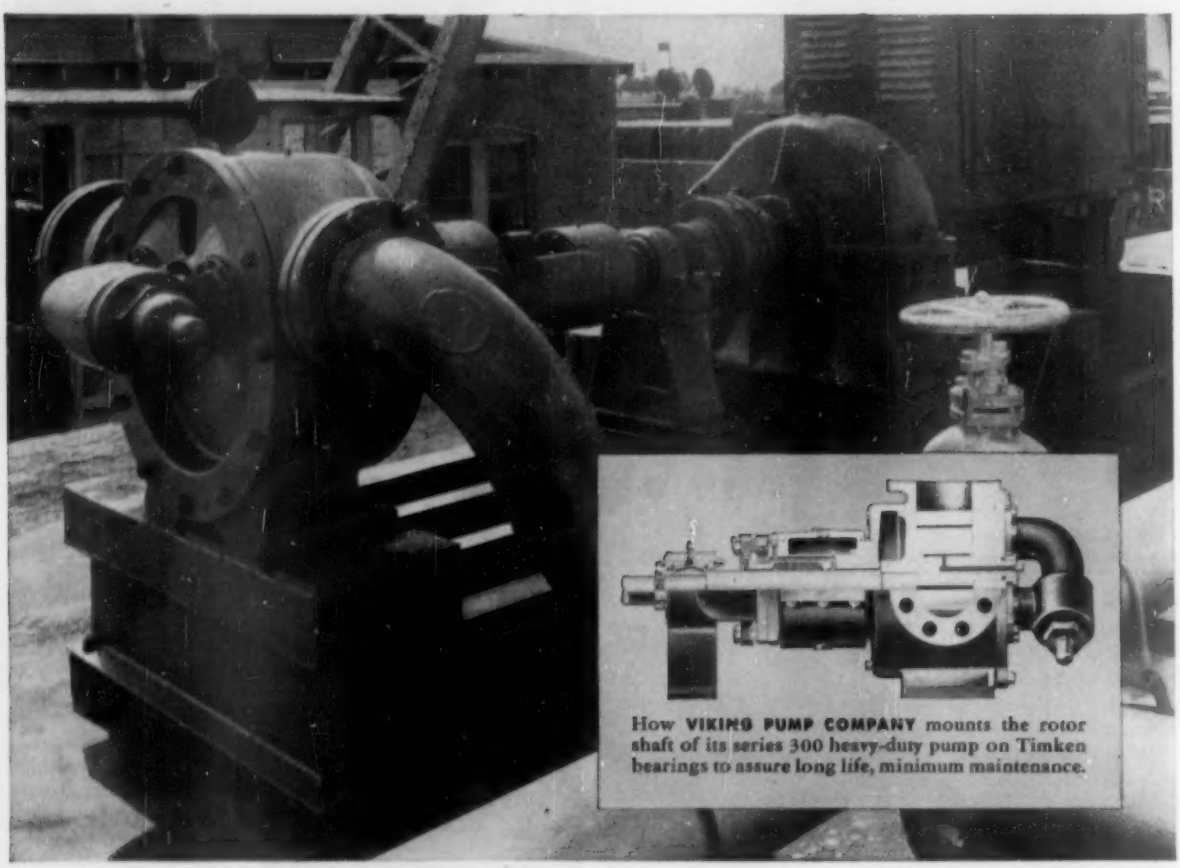
THE Viking Pump Company's series 300 heavy-duty pump was designed to give dependable performance, pumping thin or thick liquids. To make sure it delivers, Viking engineers specify Timken® tapered roller bearings for the rotor shaft.

Timken bearings provide thrust control for the large power-driven rotor shaft gear. They permit adjustments for proper end clearance and also prevent the pump rotor from wearing against the pump head. Their tapered construction lets them take heavy thrust loads as well as radial loads in any combination.

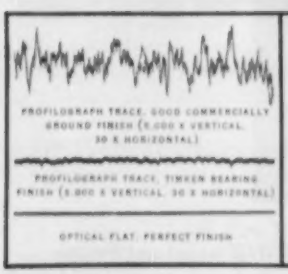
Timken bearings hold wear to a minimum because they practically eliminate friction. That's because they're designed to roll true and because they're made with microscopic accuracy to conform to their design. You're doubly assured of Timken bearings' quality because we make our own steel. No other U. S. bearing maker does.

So for long life and minimum maintenance, always specify Timken bearings. Look for the trade-mark "Timken" on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



How **VIKING PUMP COMPANY** mounts the rotor shaft of its series 300 heavy-duty pump on Timken bearings to assure long life, minimum maintenance.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PROFILOGRAPH TRACE, TIMKEN BEARING FINISH (5,000 X VERTICAL, 30 X HORIZONTAL)
OPTICAL FLAT, PERFECT FINISH

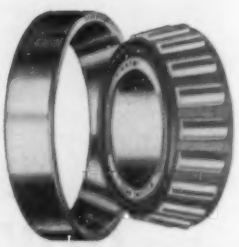
SMOOTH TO MILLIONTHS OF AN INCH

Surface finish of high quality Timken bearing rollers and races is so smooth that it takes a profilograph to measure its smoothness. This instrument measures surface variations to a millionth of an inch, as shown at the left.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS



NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ⬮ AND THRUST →⬮← LOADS OR ANY COMBINATION →✳←

● **AIR-OPERATED CLUTCHES THROUGHOUT** permit fast, effortless hoisting and lowering between trips.

● **AIR-OPERATED CONTROLS THROUGHOUT** provide air-cushioned, sensitive control of drum clutches, rotary drive and engine throttle with maximum ease of operation.

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● **HYDROMATIC BRAKE ON HOISTING DRUM,** standard equipment on "*510*" and optional on the "*340*", reduces excessive wear on brake linings and flanges throughout trip cycle, increases capacity to handle heavy loads, provides safer working conditions.

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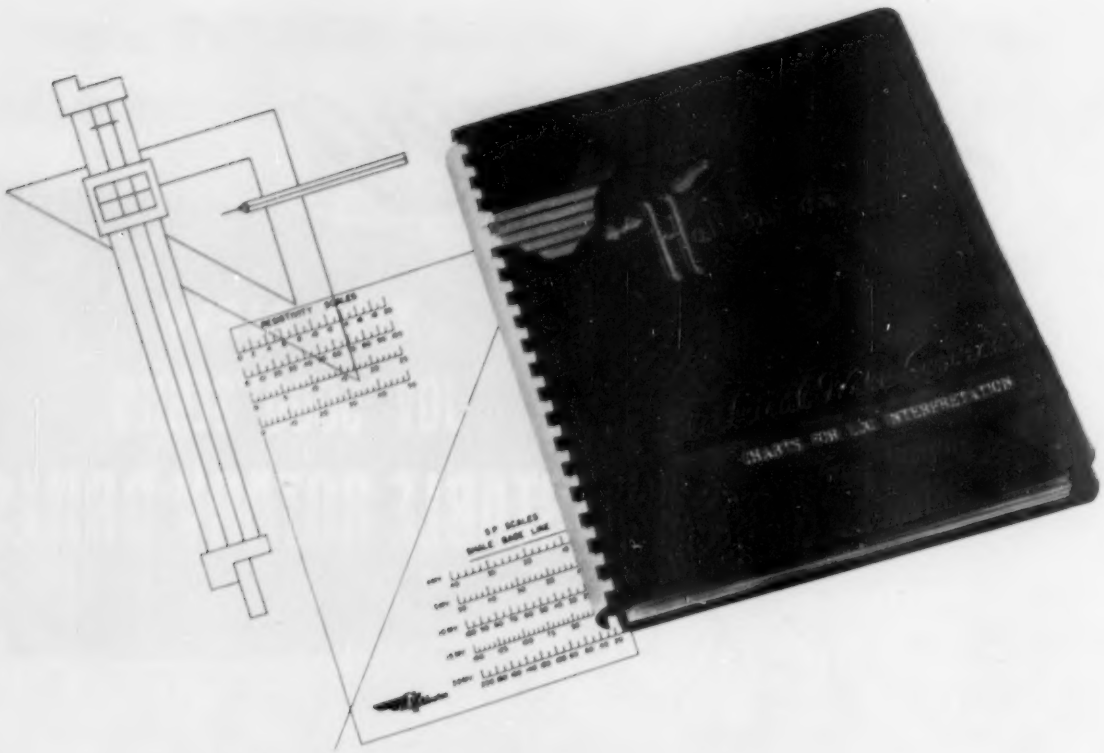


well logs interpreted with HIGH FIDELITY

When a Halliburton logging crew pulls instruments out of the hole, an equally important job has yet to be done...

It's the part performed by the Halliburton Electrical Well Services laboratory in Houston. That's where the data from your well are analyzed with the *high fidelity* that permits confident completion decisions. The Interpretive Section of the laboratory staff is composed of trained men with many years of background in log interpretation. Field personnel are trained to handle your interpretive problems locally. Unusual or specially complex evaluation problems are passed along to Halliburton's high-level analysts—petro-physicists, reservoir engineers, geologists and mathematicians whose names are familiar in the highest ranks of their profession. The pride, integrity and competence of these men are signalized by the results of their work.

The case history on the opposite page is number five in a series. It is typical of the remarkably accurate analyses turned out by Halliburton's Interpretive Section. Such consistently high fidelity of interpretation is the uppermost reason why Halliburton customers have learned they can make completion decisions with assurance.

HALLIBURTON

OIL WELL CEMENTING COMPANY

DUNCAN, OKLAHOMA

"PROGRESS IN SERVICE THROUGH RESEARCH"

LOG ANALYSIS LIKE THIS

EVALUATES *LOW-RESISTIVITY* PAY ZONES

Cockfield-Yegua Development Guided By Halliburton's Sensitive-Scale Logging

There are many producing horizons with extremely low resistivity in the Cockfield-Yegua section of the Gulf Coast of Texas. These zones are hard to recognize and evaluate when using normal sensitivity scales. But accurate amplification of resistivity scales is facilitated by advanced methods developed by Halliburton. Amplified log data guided development of this well, resulting in daily oil production figures shown.

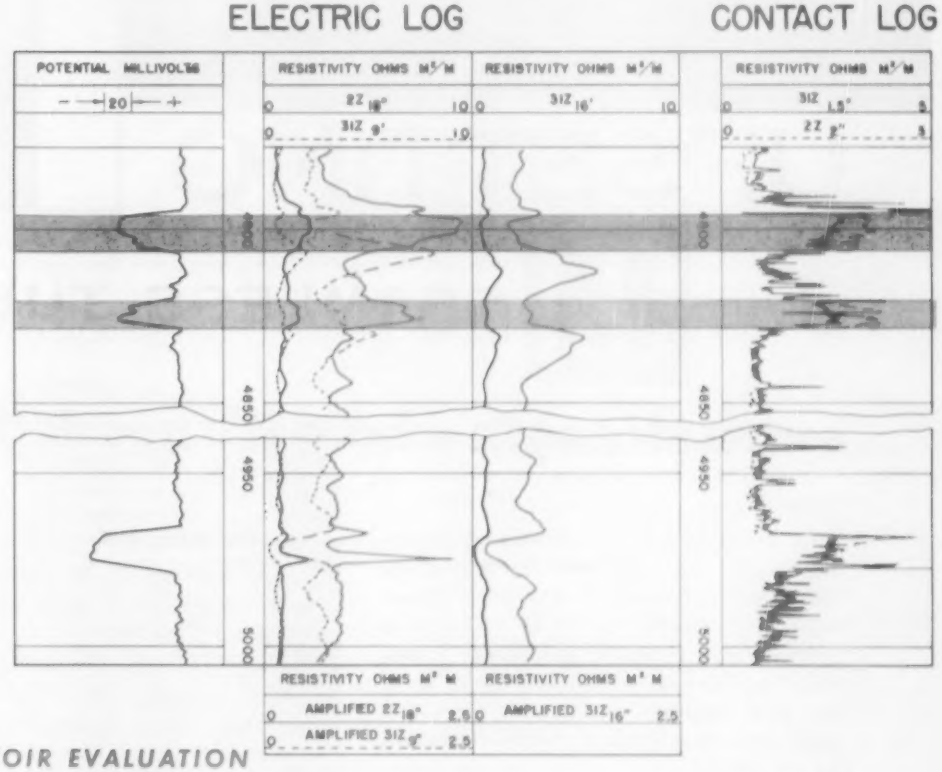
These curves show why more and more oilmen are learning to depend on Halliburton for advanced well logging to assist them in solving their problems.

Get this same high fidelity of log analysis in your own problem formations . . . call your local or district office of the Halliburton Oil Well Cementing Company.

PRODUCTION DATA

Producing Interval:
4820-28'

Initial Production:
165.8 barrels of oil per day through 11/64" choke



RESERVOIR EVALUATION

Cockfield Sand	FROM CORES	FROM LOGS
DEPTH: 4796-4807'		
POROSITY	34.1%	36.0%
WATER SATURATION	Less than 40%	29.0%
MAXIMUM RECOVERABLE HYDROCARBONS (Bbls. per acre foot)	1590	1840

Cockfield Sand	FROM CORES	FROM LOGS
DEPTH: 4821-4829'		
POROSITY	No Cores Available	35.0%
WATER SATURATION		36.0%
MAXIMUM RECOVERABLE HYDROCARBONS (Bbls. per acre foot)		1520

COMPLETE DATA SENT ON REQUEST

Add this valuable information to your Halliburton Service File.

HALLIBURTON ELECTRICAL WELL SERVICES

UPSETTING

gives CF&I SEAMLESS TUBING

extra strength where it's needed most

The tremendous strain imposed on oil tubing joints, especially near the top of the well, demands exceptional strength. Since threading weakens tubing at the joints, a special forging process known as "upsetting" was devised to increase the O. D. of the tube ends without altering the inside diameter—to provide greater wall strength at the joints.

At CF&I's upsetter, both ends of the tube are heated to forging temperature, upset and allowed to cool. When required by specifications the tube is normalized. Then the ends are faced and chamfered.

After inspection, the tubing is sent to the threader. Thread protectors and couplings are applied, tubing is sorted for length, tested and coated for delivery.

Rigid manufacturing standards, testing and re-testing, are typical of the care CF&I exercises from mine through manufacture. Thus, in CF&I Seamless Oil Country Casing and Tubing (available in sizes 2⅜" through 9⅝" O. D.), you are assured materials that meet or exceed standards set by API Specification 5A.

SEAMLESS TUBULAR PRODUCTS

THE COLORADO FUEL AND IRON CORPORATION

DENVER, COLORADO

CF&I

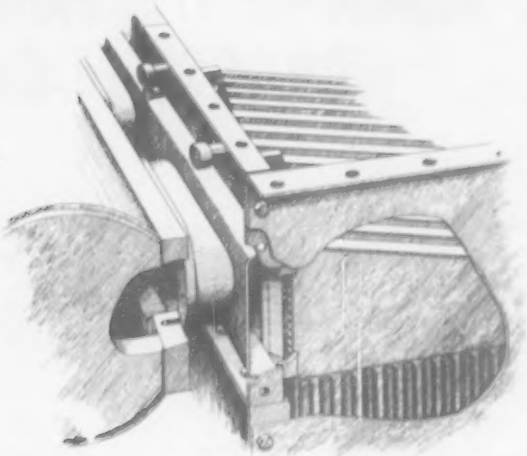
3372

how

a

PIN-FIN

extended-surface regenerator



Detail sketch showing specially designed 'pin-like' shapes which greatly increase heat-transfer surface area.

adds to economy of gas-turbine operation . . .

Compact, light-weight PIN-FIN Regenerator unit.

REDUCED FUEL CONSUMPTION is a principal reason. For example, a 75%-effective Air Preheater PIN-FIN Regenerator in a gas-turbine cycle at 6 to 1 pressure ratio and a turbine inlet of 1500 F, will cut fuel consumption by about 32%.
And, just as important, is the fact that these regenerators need practically no maintenance. That's been proved by five years of actual field service.
Get the complete story of what a PIN-FIN Regenerator can do for you – call or write the Air Preheater Corporation.

Mechanical Advantages of Air Preheater's PIN-FIN Regenerator...

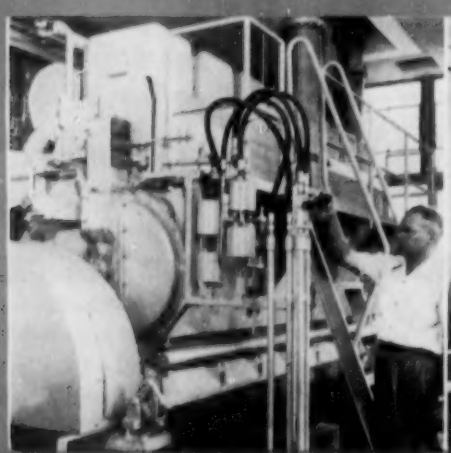
- Compact
- Light-weight
- Quickly erected
- Minimum maintenance
- Convenient, one-unit design
- Easily disassembled

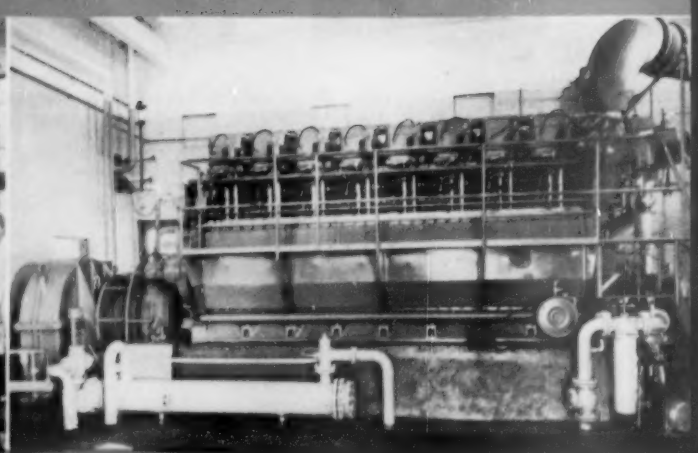
Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.

NORDBERG ENGINES

Provide Low Pipe Line Transportation Costs ACROSS the Continent

• Each year there are more and more Nordberg engines installed by pipe lines. The reasons are sound . . . these compact, more powerful engines efficiently meet the operator's requirements for all types of pumping.



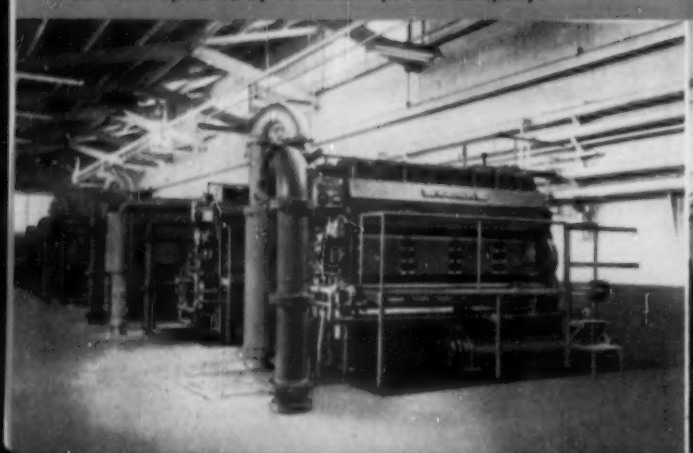


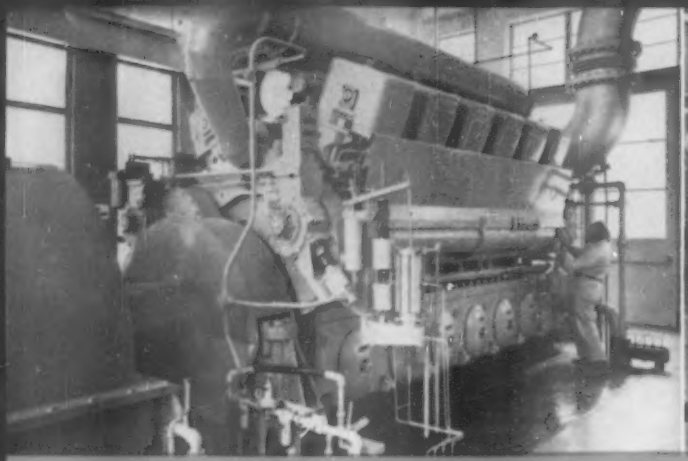
• One of two Nordberg eight cylinder, 1210 hp Supercharged Diesels on Shell Oil Company's Weed River products pipe line.

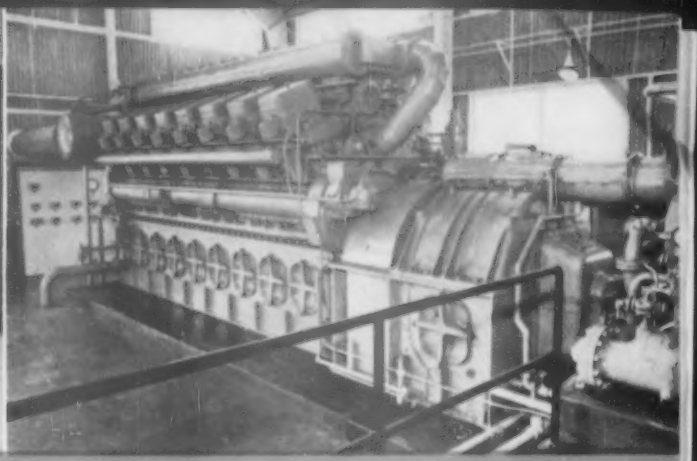
• Four of the 23 Nordberg engines installed in stations along the Rangeley, Colo.-Salt Lake City crude and products lines operated by Salt Lake Pipe Line Company.

• One of nine Nordberg eight cylinder, 13" bore SUPAIR-THERMAL® Dualfuel engines operating on a Phillips Pipe Line Company products line.

• Twelve of these Nordberg SUPAIRTHERMAL engines provide a total of 22,680 hp for pumping stations along the Lakehead Pipe Line Company's line.





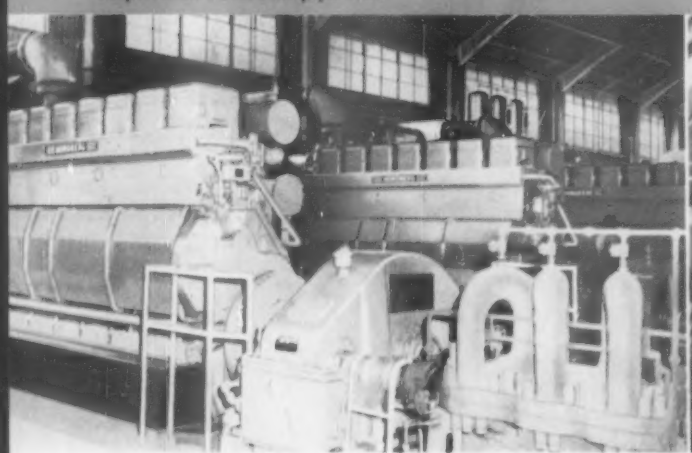


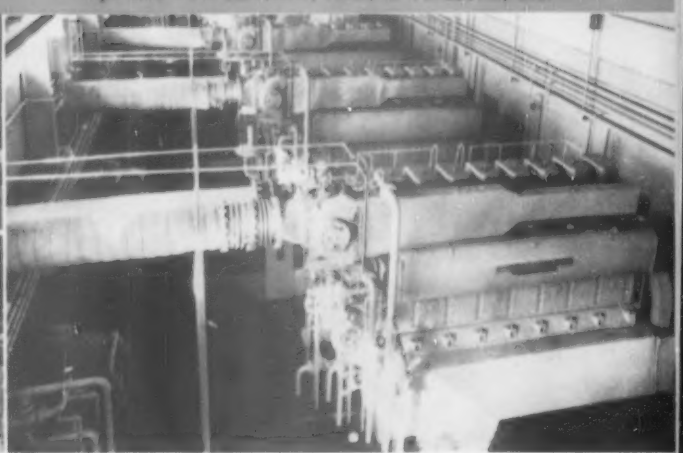
• Nordberg 2650 hp automatically-controlled SUPAIRTHERMAL V-type Diesel furnishes all power for the Vicksburg, Mich., station on the Wolverine Pipe Line Company's products line.

• Three of six Nordberg 1050 hp Duafuel engines installed in the Tejon and Wheeler Ridge stations of Richfield Oil Corporation's crude oil pipe line.

• 3000 hp Nordberg V-type SUPAIRTHERMAL Spark-Ignition Engine Gear Set driving a centrifugal gas compressor in Transcontinental Gas Pipe Line Corporation's Station 23 near Houston, Texas.

• Three of 12 Nordberg SUPAIRTHERMAL engines, totalling, over 20,000 hp, installed along the Trans Mountain Pipe Line from Edmonton, Alta., to Vancouver, B.C.





SUPAIRTHERMAL® ENGINES

the logical choice for these basic power jobs:

- PIPE LINE PUMPING
- GAS COMPRESSOR DRIVE
- POWER GENERATION

Nordberg four-cycle Supairthermal engines are available in a full range of sizes from 535 to 5000 hp for Diesel, Duafuel® or Spark-Ignition Gas operation, including both In-line and "V" types. The Supairthermal principle increases the engine's load-carrying ability over a wide speed range. This reserve power is like "money in the bank" when additional capacity is needed. We welcome your inquiry and the opportunity to assist you with your power study.

NORDBERG MFG. CO., Milwaukee, Wis.

Builders of America's Largest Line of Heavy Duty Engines—10 to over 12,000 Horsepower

NORDBERG

DIESEL • DUAFUEL® AND SPARK-IGNITION GAS ENGINES

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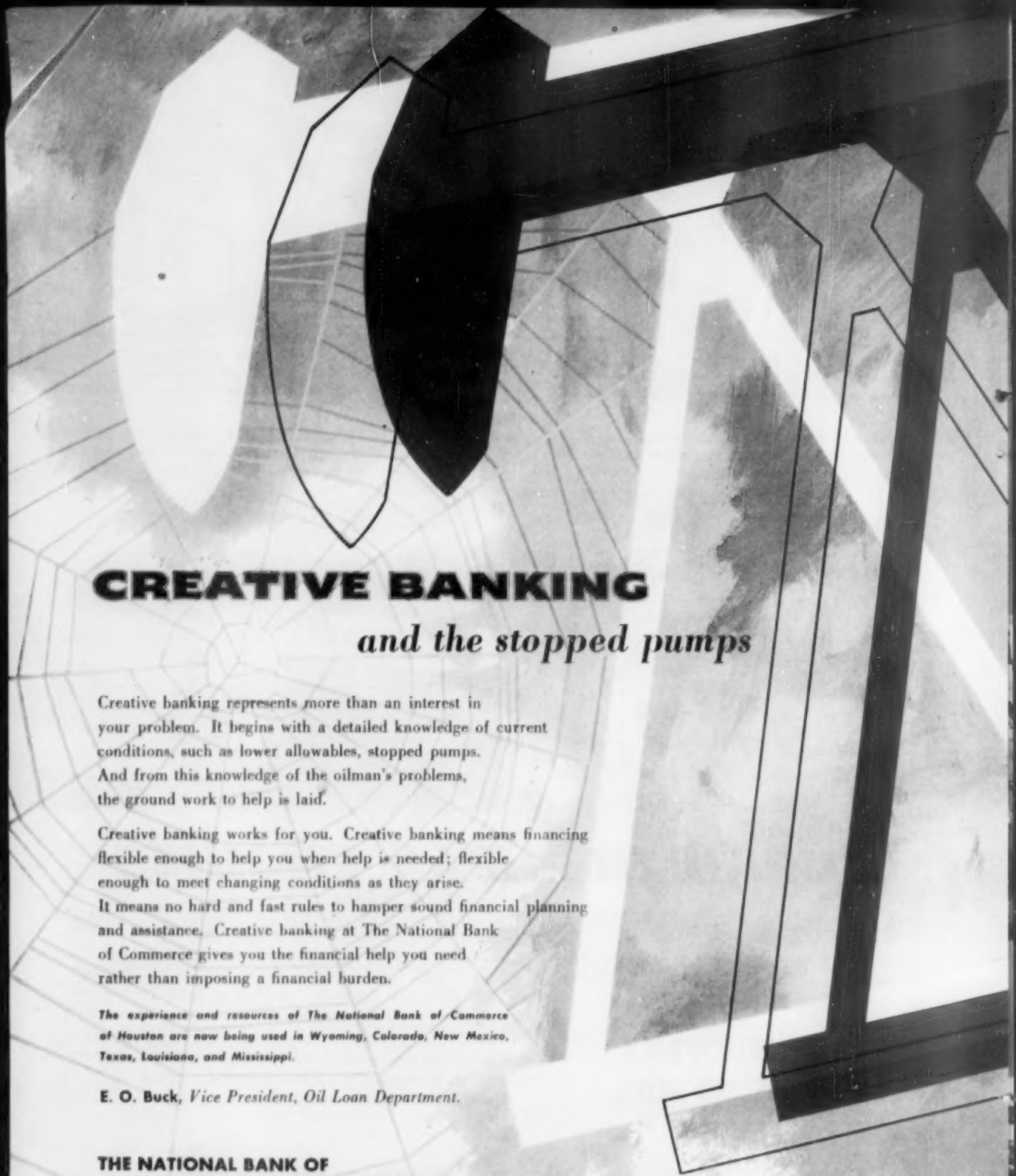


CREATIVE BANKING

and the stopped pumps

Creative banking represents more than an interest in your problem. It begins with a detailed knowledge of current conditions, such as lower allowables, stopped pumps. And from this knowledge of the oilman's problems, the ground work to help is laid.

Creative banking works for you. Creative banking means financing flexible enough to help you when help is needed; flexible enough to meet changing conditions as they arise. It means no hard and fast rules to hamper sound financial planning and assistance. Creative banking at The National Bank of Commerce gives you the financial help you need rather than imposing a financial burden.

The experience and resources of The National Bank of Commerce of Houston are now being used in Wyoming, Colorado, New Mexico, Texas, Louisiana, and Mississippi.

E. O. Buck, *Vice President, Oil Loan Department.*

THE NATIONAL BANK OF

COMMERCE

OF HOUSTON *Gulf Building — 712 Main Street, Houston, Texas*

MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

The right Axelson pump will give you more oil and less trouble.

Your J&L store has that pump and can prove its performance with local case histories.

Let J&L help. Axelson pumps are made and can be assembled in infinite variety. No J&L customer is ever obliged to use a square peg in a round hole.

Nor does J&L ever consider an Axelson sale final. J&L pump repair shops stand by in the United States and Canada with parts and service. Never junk an Axelson. Never accept a substitute.

Pump for more profit . . . get J&L on the telephone now.

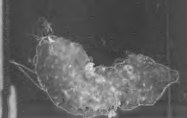
J&L Casing and Tubing, Cabot Pumping Units, Axelson Sucker Rods — these are also select and important elements in the proven J&L formula for MORE OIL, LESS TROUBLE.

Axelson deep well plunger pump, "TLE" tubing liner type.

J&L

Profit Formula for Producers

MORE OIL
LESS TROUBLE



Jones & Laughlin

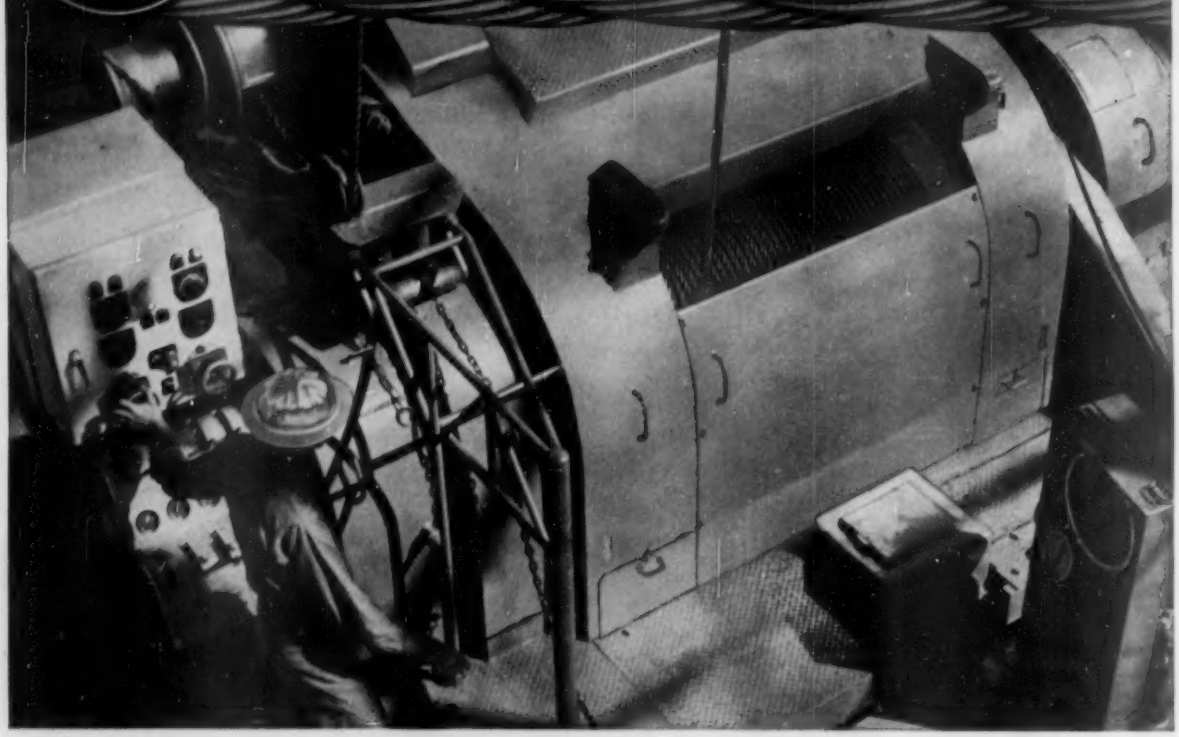
SUPPLY DIVISION – Tulsa

SERVING THE UNITED STATES AND CANADA

8-G

an ACCO product

American Cable TRU-LAY VHS | 15% STRONGER



Drill Deeper and Faster with New VHS Rotary Drilling Lines

Drillers in every part of the oil country are proving to themselves the benefits of new VHS Rotary Drilling Lines. Made of a new grade of steel for wire rope, these new VHS lines are 15% stronger than Improved Plow Steel—the strongest available up to now. The new VHS is tougher, too. It gives you many important advantages, including:

Higher Factor of Safety

Careful calculations show that the factor of safety for 10 lines of TRU-LAY VHS rope is 14.9% or 15% higher than for 10 lines of IPS rope. To say it another way, the factor of safety for 12 lines IPS is almost identical to 10 lines of VHS rope. This alone would be reason enough to order VHS rope.

Faster Drilling—Less "Down Time"

With new VHS, you can drill deeper before increasing the number of parts of line. And VHS's extra strength eliminates, in many cases, any necessity for buying new blocks or regrooving sheaves to use larger diameter lines for higher safety factors.

Tougher

Because TRU-LAY VHS is stronger *and* tougher, it has greater resistance to abrasion and higher resistance to peening . . . both important factors in maintaining shape and diameter. Ton-mile advantages should result if regular adaptable cut-off practices are followed.

Simple Ordering Procedure

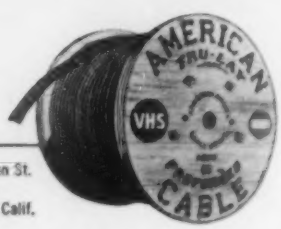
Nothing could be simpler than ordering VHS Rotary Drilling Lines. Just ask your nearest Mid-Continent Supply store for a new VHS drilling line in the length and diameter you need.

For further information write to the nearest American Chain & Cable Company office listed at right for
Brochure DH-516H

ACCO
TRADE MARK

American Cable Division
AMERICAN CHAIN & CABLE

630 McFarland St. Houston 1, Texas | 4555 E. 46th Ave. Denver 16, Colorado | 2216 S. Garfield Ave. Los Angeles 22, Calif. | 400 W. Madison St. Chicago 6, Ill.
Wilkes-Barre, Pa.; Odessa, Texas; New York, N.Y.; Philadelphia, Pa.; San Francisco, Calif.



SHARP

Teeth that really dig

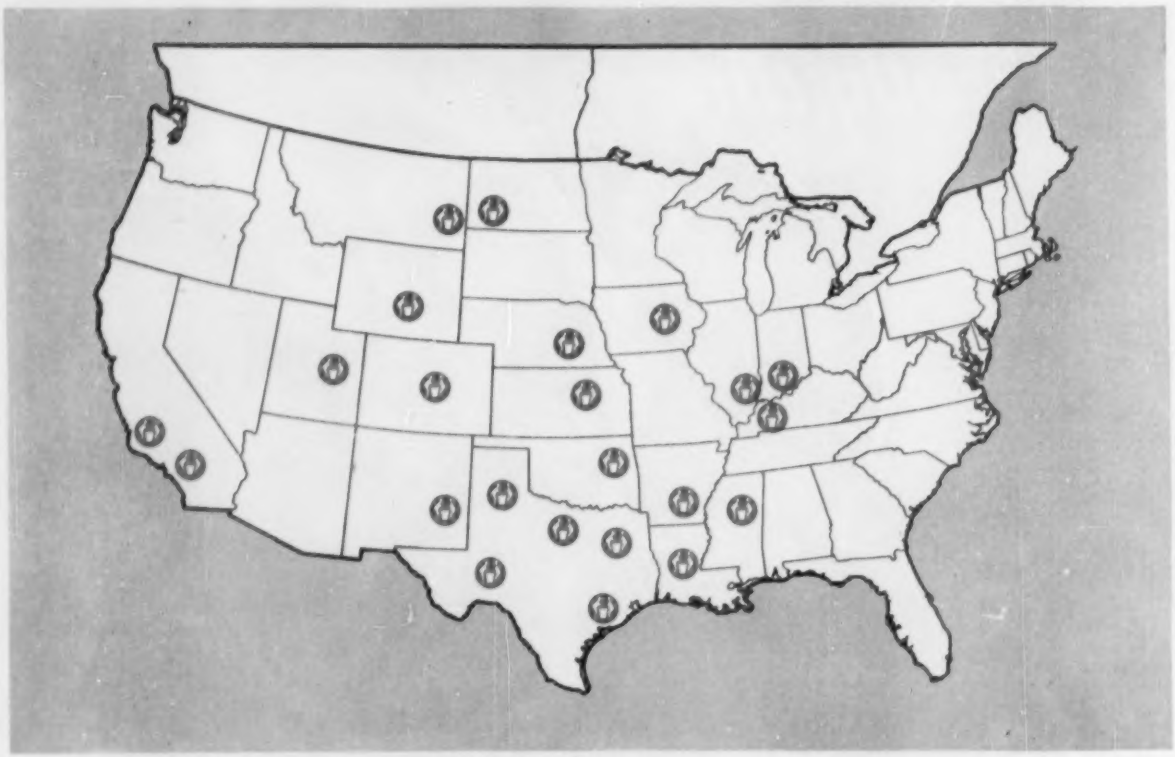
There is no substitute for
ROLLED ALLOY STEEL
HAMMER FORGED

H & L TOOTH CO.

1540 SO. GREENWOOD AVE.,
MONTEBELLO, CALIFORNIA

25th *Silver Anniversary*

Financing from the **FIRST** *in Dallas goes where you go!*



- Straight collateral loans on oil or gas producing properties, secondary recovery, refining plants, pipe lines and progressive loans.
- Oil and gas payment loans.

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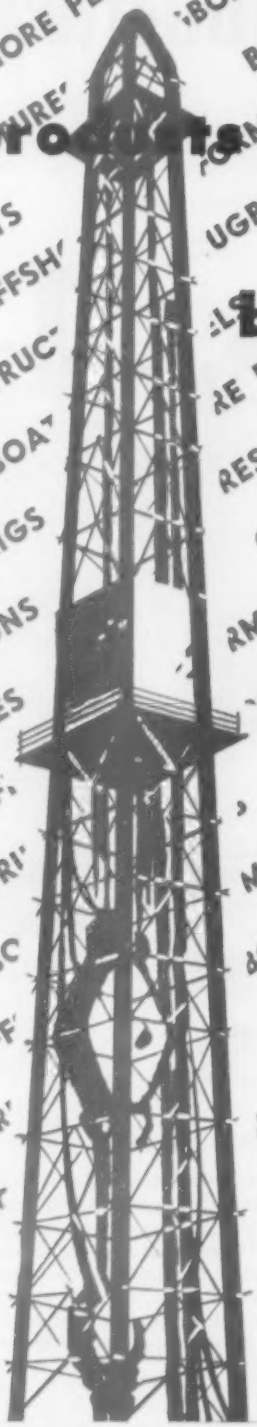
GIVE US AN OPPORTUNITY TO SAY · SBA ·

put FIRST financing in your own oil future

Products for the Oil Industry by Avondale



products by AVONDALE . . . offshore drilling platforms, drilling barges, towboats, tugboats, barges—any and all kinds of marine equipment for the Oil Industry! AVONDALE products are in step with the fast-moving Oil Industry. AVONDALE products are known and famous in the Oil Industry. If you are considering construction or repairs—call on AVONDALE!

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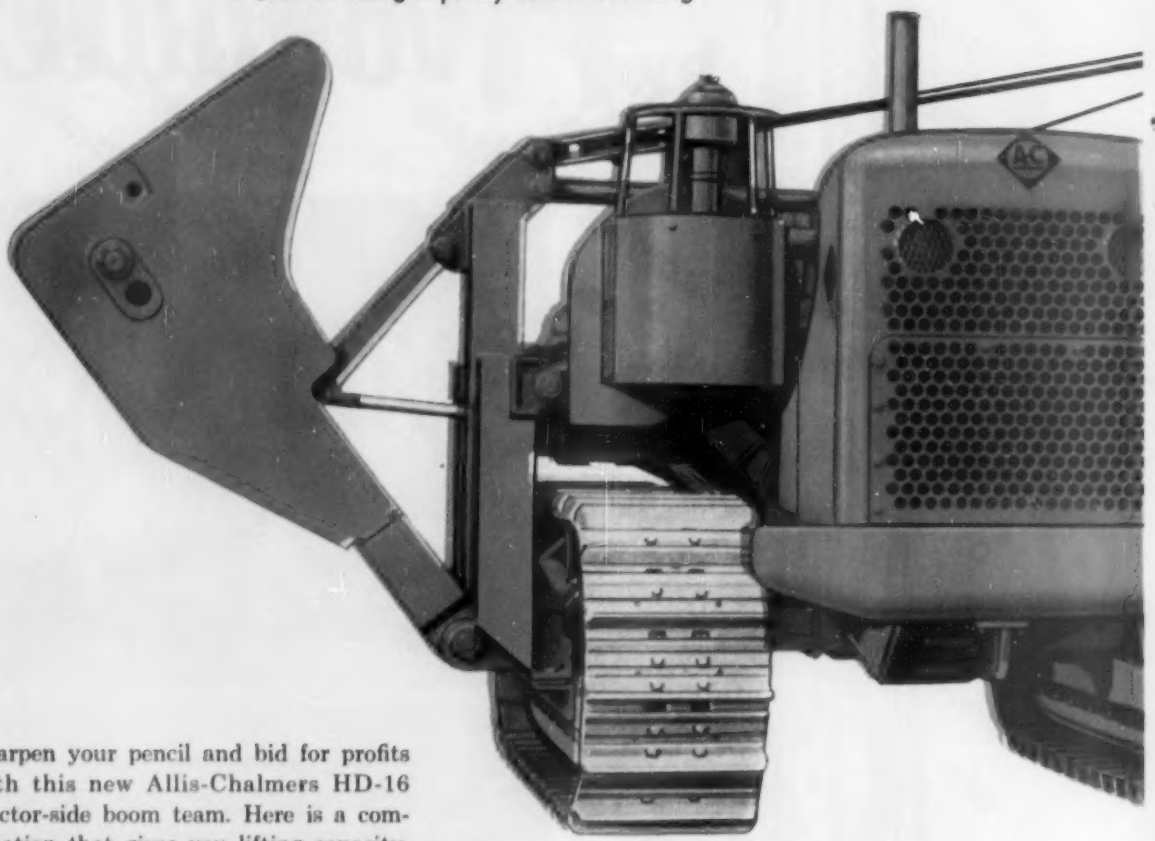
P.O. BOX 1030 • PHONE UNiversity 6-4561 • NEW ORLEANS 8, U.S.A.

Another New Big Production

150 net engine hp

Weight — 57,840 lb, tractor and side boom with full counterweight

77,500-lb lifting capacity at 4-ft overhang



Sharpen your pencil and bid for profits with this new Allis-Chalmers HD-16 tractor-side boom team. Here is a combination that gives you lifting capacity, stability and safety to take on big pipeline jobs—yet keeps operating costs down.

• New Allis-Chalmers Engine

This Allis-Chalmers heavy-duty diesel engine offers quick starting with smooth, long-life performance. High power output with big reserve capacity means low maintenance costs.

• Proved Torque Converter Power

The HD-16 gives you the outstanding advantages of proved torque converter drive — smooth, cushioned power for tractor and boom, most shifting eliminated so operator can concentrate on pipe work. With full horsepower available at all times, the HD-16 matches speed perfectly to slow-moving clean-prime, dope-wrap machines, even on steep grades.

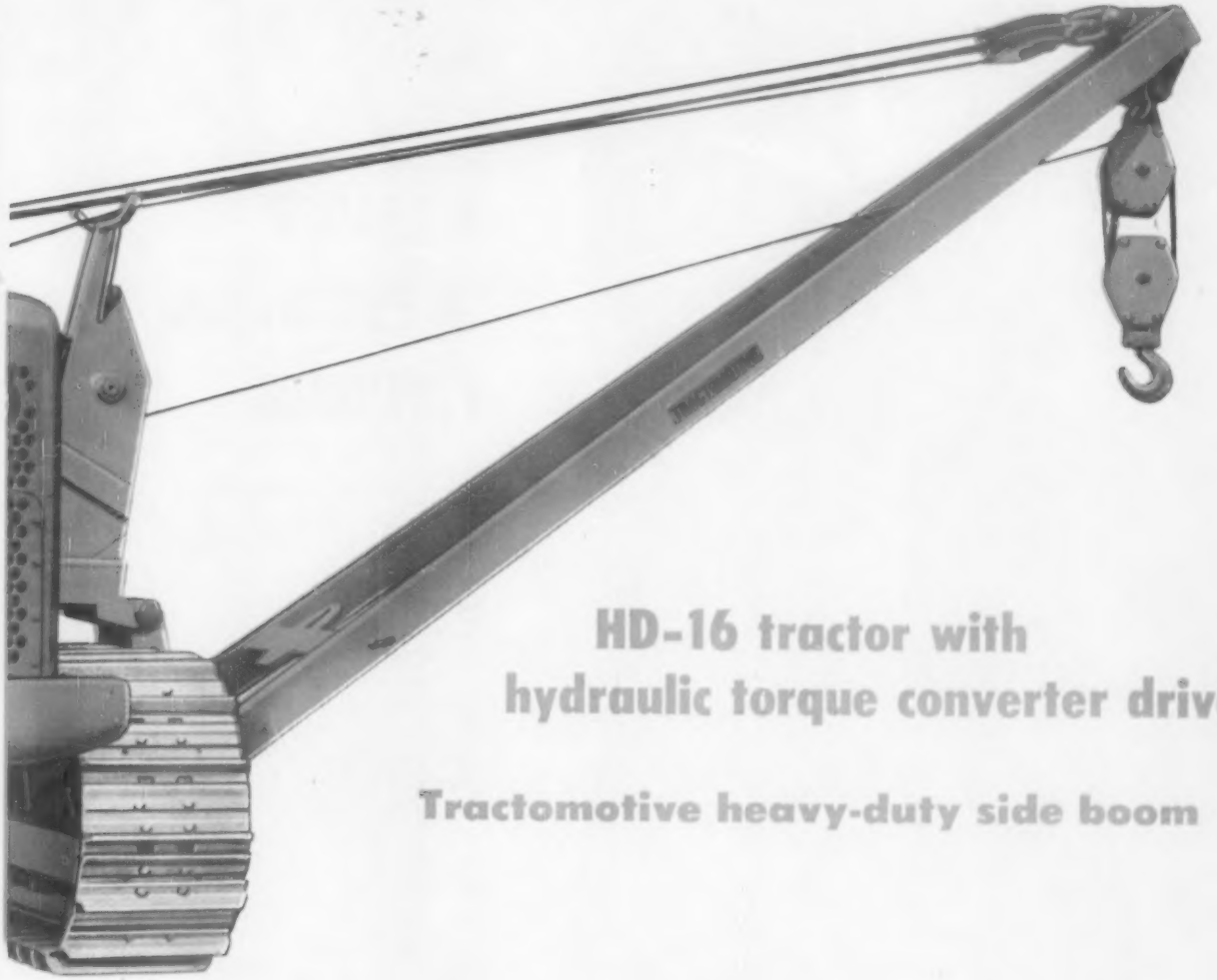
• Unmatched Stability in Its Size Class

Eighty-four in., center-to-center tread width, up to 24-in. track shoes and long track with seven heavy-duty truck wheels give this crawler tractor balance and stability to boom out the big loads. Double reduction final drives and smooth, clean bottom construction provide extra clearance to skim over obstacles. And with torque converter permitting tractor to ease smoothly into motion, there's no tendency for tracks to dig in.

• Easy to Operate and Service

With direct electric starting on diesel fuel, hydraulic, finger-tip steering, self-energizing brakes and comfortable foam-rubber seats, operator gets more work done. You save on maintenance time with such outstanding features as simplified adjustments, fewer lubrication points and 1,000-hour lubrication periods for truck wheels, idlers and support rollers.

Pipe Team *from Allis-Chalmers*



HD-16 tractor with hydraulic torque converter drive

Tractomotive heavy-duty side boom

• Safe, Husky Side Boom

Side boom features drop-proof safety counterweights; internal expanding brakes, fully enclosed from dirt and moisture; easy-working, convenient controls; and constant mesh transmission. It's built to take full advantage of the HD-16's big lifting capacity.

• Big Output – All the Way

The HD-16 is newly engineered throughout to give you big safety factors and long life in every component. This tractor, whether equipped with dozer or side boom, will give you big production under tough, as well as average, conditions — help you hold down costs on every job you bid.

ALLIS-CHALMERS, CONSTRUCTION MACHINERY DIVISION, MILWAUKEE 1, WISCONSIN

ALLIS-CHALMERS

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Leadership is earned only by performance.

Performance — consistent, dependable, alert — has brought to our Petroleum Department outstanding producers who know we understand the problems of petroleum financing. In Republic's Oil Department, the first and most important question is always . . .

"WHAT CAN WE DO FOR YOU?"

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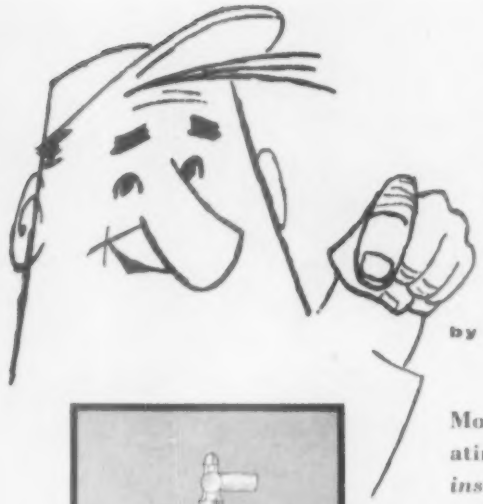
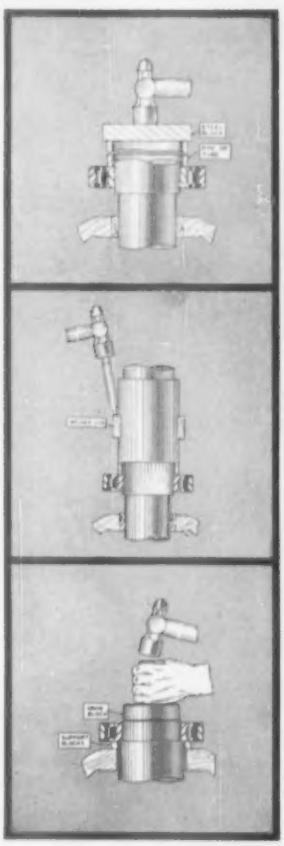
CAPITAL AND SURPLUS $70,000,000 • LARGEST IN THE SOUTH



How to press a Hyatt Bearing off or on

by HY WHEELER, the sage of the socket wrench



Most bearing damage results from improper operating conditions, or from *improper handling during installation and removal.* A little extra care in pressing bearings on or off may save a lot of time and money in the long run!

The best thing to use is an *arbor press* or a *bearing puller.* If neither is available, or can't be used, you can drive the bearing with a hammer—but *be careful to avoid injury to yourself or damage to the bearing.* REMEMBER:

1. Always direct the force *against the face of the press-fitted race* (usually the rotating one) to avoid damage to separators, rollers, etc.

2. Never hammer directly on races or separators and never use a wood or soft metal mallet; chips or splinters may get into the bearing.

3. In driving, use many smart, quick taps alternately on opposite sides to prevent the race from cocking and harming the shaft.

4. *Make sure your hands, tools and surroundings are clean—dirt quickly ruins bearings.*

AND ALWAYS REPLACE A HYATT WITH ANOTHER HYATT TO ASSURE PERFECT FIT AND PERFORMANCE. REMEMBER, WHEN IT COMES TO QUALITY...

there's no substitute for...

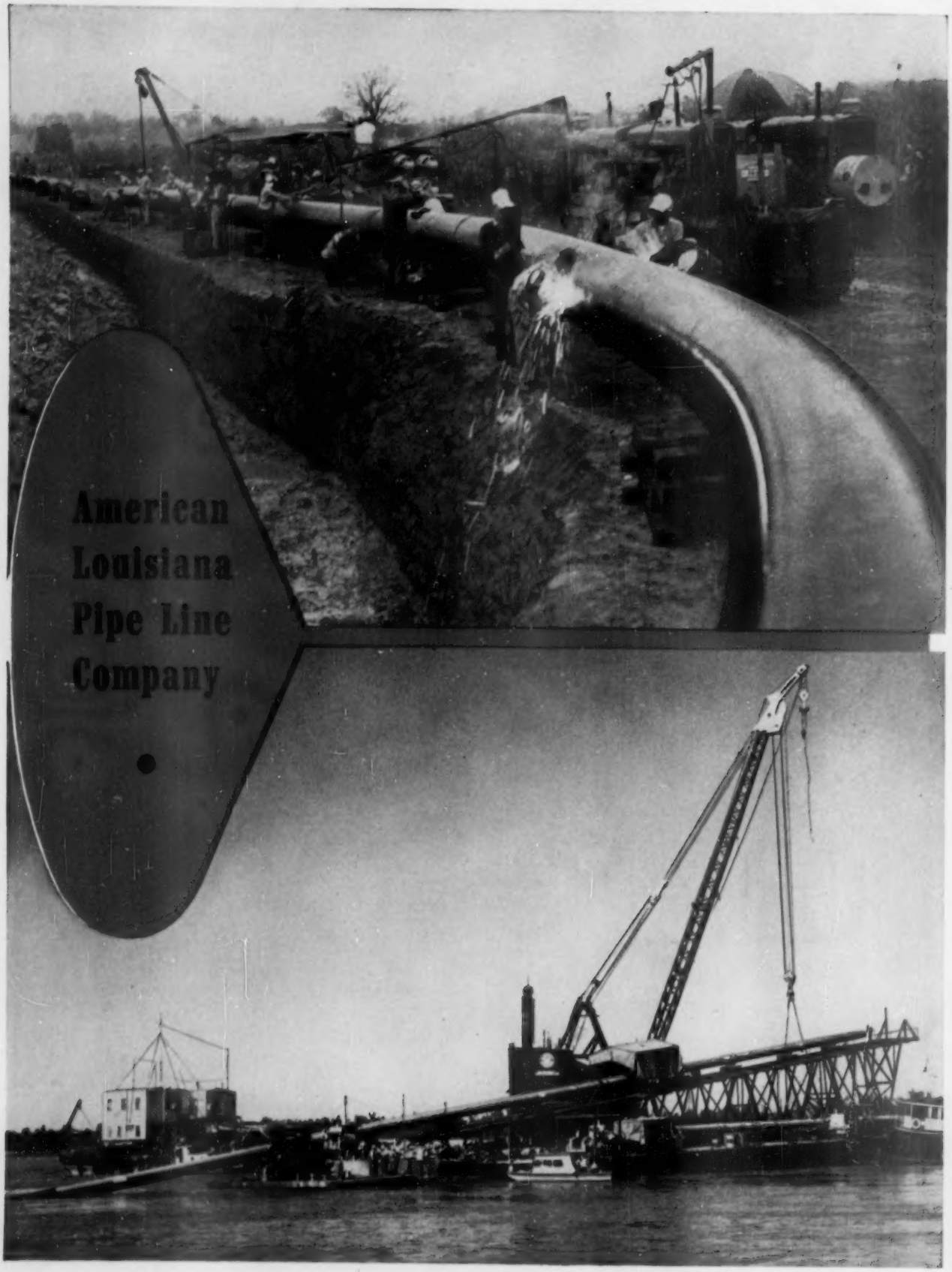
AVAILABLE THROUGH UNITED MOTORS DISTRIBUTORS

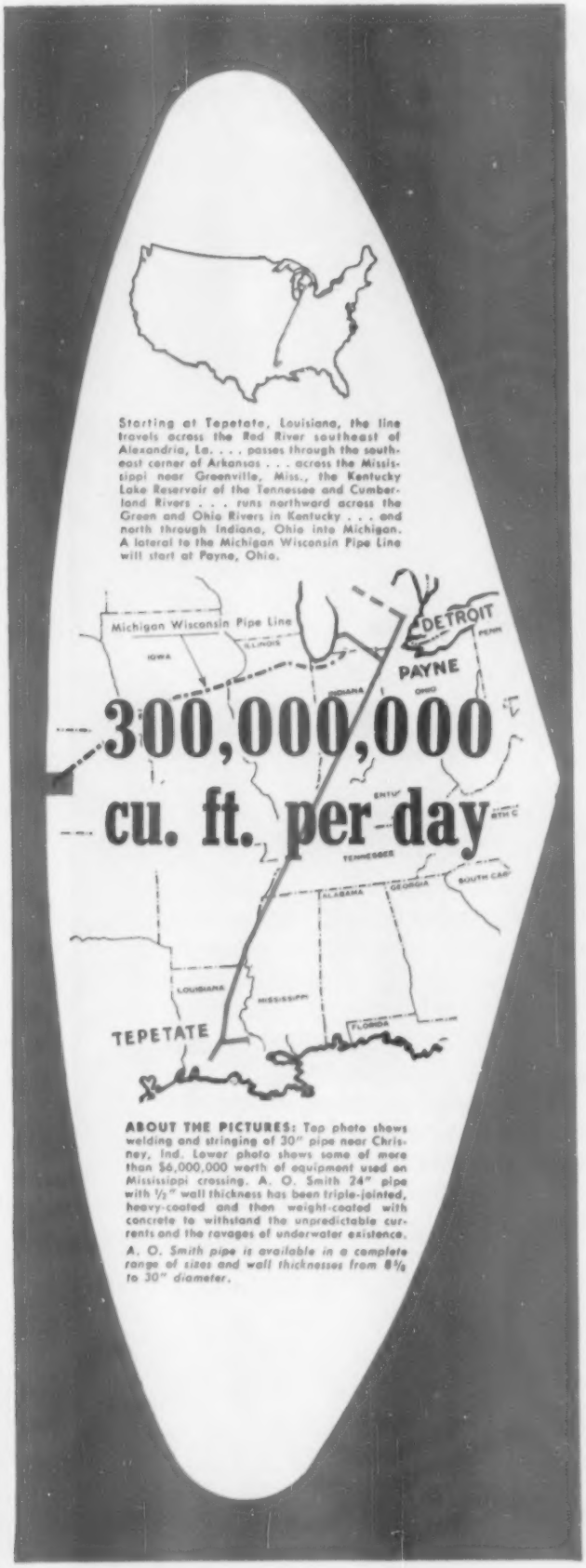
GM PARTS SALES

HYATT ROLLER BEARINGS

STRAIGHT BARREL TAPER

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION • HARRISON, NEW JERSEY


American
Louisiana
Pipe Line
Company


Starting at Tepetate, Louisiana, the line travels across the Red River southeast of Alexandria, La. . . . passes through the southeast corner of Arkansas . . . across the Mississippi near Greenville, Miss., the Kentucky Lake Reservoir of the Tennessee and Cumberland Rivers . . . runs northward across the Green and Ohio Rivers in Kentucky . . . and north through Indiana, Ohio into Michigan. A lateral to the Michigan Wisconsin Pipe Line will start at Payne, Ohio.
Michigan Wisconsin Pipe Line
DETROIT
PAYNE
300,000,000
cu. ft. per day
TEPETATE
ABOUT THE PICTURES: Top photo shows welding and stringing of 30" pipe near Chrisney, Ind. Lower photo shows some of more than $6,000,000 worth of equipment used on Mississippi crossing. A. O. Smith 24" pipe with ½" wall thickness has been triple-jointed, heavy-coated and then weight-coated with concrete to withstand the unpredictable currents and the ravages of underwater existence.
A. O. Smith pipe is available in a complete range of sizes and wall thicknesses from 8⅝ to 30" diameter.

793 Miles of A. O. Smith Line Pipe

THE new American Louisiana Pipe Line is being built to meet the tremendous requirements for additional supplies of natural gas in Michigan, Wisconsin and parts of Iowa and Missouri. When complete it will bring 300,000,000 cu ft of gas per day to these states. This capacity can be increased to 550,000,000 feet per day by the addition of compressor horsepower.

The main line will be 30" in diameter and extend 1000 miles from southern Louisiana to a connection with Michigan Consolidated Gas Company at Willow Run. It will cross 8 states and nine major rivers and lakes, marshes, swamps, rice fields, forests and the mountains of Tennessee, Kentucky and southern Indiana. Also, approximately 78 miles of 24" and 26" main line will be laid in southern Louisiana.

The pipe line system was designed by Ford, Bacon & Davis, Inc., and construction is being done by H. C. Price Company, Houston Construction Company and Brown & Root, Inc.

A. O. Smith Corporation played an important part in this new line by furnishing 758 miles, over 75%, of the 30" pipe from its Houston Mill, A. O. Smith Co. of Texas, and 35 miles of the 26" pipe, together with the 24" heavy wall pipe used for the major river crossings, from its Milwaukee Mill.

For almost 30 years A. O. Smith has held a high-standard of quality control and this quality control has been maintained at every step of the manufacturing process. That's why A. O. Smith pipe made and installed in 1928 is still in operation. That's why so much A. O. Smith pipe has been used in nearly every important high pressure line.

Through research ... *a better way*

A.O.Smith

CORPORATION

TUBULAR PRODUCTS DIVISION

Milwaukee 1, Wisconsin

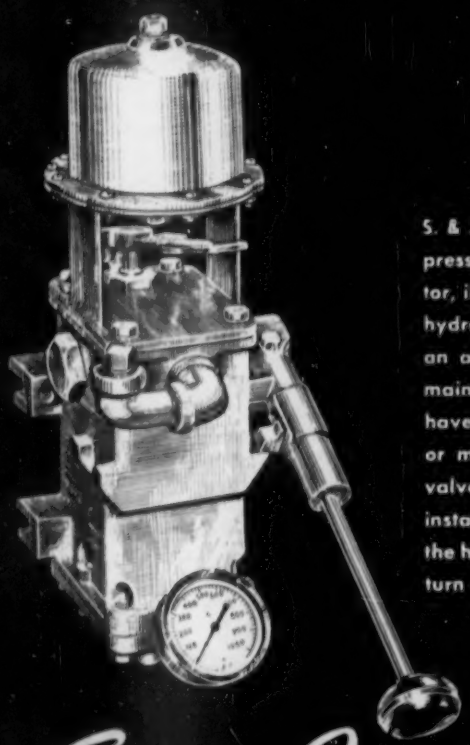
Chicago 4 • Dallas 2 • Los Angeles 22 • Midland 5, Texas • New Orleans 12 • New York 17 • Pittsburgh 19 • San Francisco 4 Seattle 1 • Tulsa 3 • Washington 6, D. C.

International Division: Milwaukee 1, Wisconsin

S&J HYDRAULIC SAFETY VALVES

for Storage Tanks and Pipe Lines

Pictured here are two Shand & Jurs products which are the key components of the S. & J. Internal Hydraulic Safety Valve System for handling petroleum products through high pressure storage tanks and pipe lines, a system that enhances your Safety Factor appreciably, and safeguards your equipment in event of exposure fires. The S. & J. hydraulically operated valve shown at the right is located in the discharge opening of the tank. It has a cast steel base and is recommended for operating conditions up to 300 pounds. In pipe line service the valve is installed in a pipe line spool. The valve base is sandwiched between two pipe flanges and the periphery of the valve base is the only portion exposed.



S. & J. Hydraulic Valves are normally held closed by spring pressure, and can be opened by the S. & J. Hydraulic Operator, illustrated at the left, or by a small electrically operated hydraulic pump. This special Hydraulic Operator embodies an air pressure chamber with piston and stem, for use in maintaining pressure in the hydraulic system, once the valves have been opened. Release of this air pressure by automatic or manual means, in case of an emergency, permits the valves to close. Fusible plugs which melt at 165° F. are also installed at strategic points in the hydraulic line and release the hydraulic pressure automatically in event of fire, which in turn closes all valves held open under pressure.

Shand and Jurs Co.
BERKELEY 10, CALIFORNIA

NEW YORK
347 Madison Ave

HOUSTON
M & M Bldg

TULSA
Thompson Bldg

CHICAGO
10409 S Western Ave

LOS ANGELES
6399 Wilshire Blvd

REPRESENTATIVES:
SEATTLE: Nebar Supply Company, 3000 Western Avenue
MONTREAL: Lytle Engineering Specialties, Ltd., 360 Notre Dame St., W.
TORONTO: Lytle Engineering Specialties, Ltd., 69 Eglinton East.
VANCOUVER: P. D. McLaren & Son, Ltd., 3277 Main Street
CALGARY: P. D. McLaren & Son, Ltd., 510 - 9th Ave. W.
MEXICO, D.F.: Dalmar Comercial, S. A.
CARACAS: Sinclair Spence, C.A., Edificio Galipan
ENGLAND: Whessoe, Ltd., Sales: 75 Victoria St., London S. W. 1
Whessoe, Ltd., Works: Darlington, County Durham

Pittsburgh offers you the skill and knowledge of its

415 Finishes Technologists

to develop for you more durable anti-corrosive coatings for structures and facilities and more efficient ways to apply them . . . without adding to your payroll.

● **Pittsburgh Plate Glass Company's** new Paint Research Center at Springdale, Pa., contains the most modern laboratories devoted exclusively to the creation and experimental production of new finishes.

● **A necessary part** of research and development is the formulation of new chemical vehicles to improve adhesion and durability of finishes for the petroleum industry.

Now you can get tailored-for-you finishes for oil and gasoline storage tanks that give greater protection against the destructive effects of corrosion and weather. Pittsburgh places at your disposal the most modern laboratories for fundamental and applied research in the paint industry.

● **In its modern** Paint Research Center at Springdale, Pa., and the development departments of its 11 paint plants, Pittsburgh maintains a staff of 415 highly trained chemists, engineers and technicians. The creative work of this group is supported in a practical way by an experienced field sales and service staff.

● **From this group** have come many important developments in finishes for the petroleum industry. Among these is Pittsburgh's brilliant synthetic white TANKHIDE Double Cover. This is a combination of intensely white controlled-chalking titanium pigments and weather-resistant vehicles. One spray coat of TANKHIDE Double Cover produces the same film thickness as two coats of conventional synthetic white finish. This results in labor savings up to 25% as reported by painting contractors.

● **TANKHIDE'S** gleaming whiteness is maintained throughout its life by self-cleaning action. Besides brilliant white, TANKHIDE is also available in colors.

● **Bring your refinishing problems to us.** You can have the benefit of the creative ability of our technologists to help you develop superior coatings for your structures and facilities, without adding to your payroll. Pittsburgh Plate Glass Company, Industrial Finishes Division, 1 Gateway Center, Pittsburgh, Pa.

PITTSBURGH PAINTS

PAINTS • GLASS • CHEMICALS • BRUSHES • PLASTICS • FIBER GLASS

PITTSBURGH PLATE GLASS COMPANY

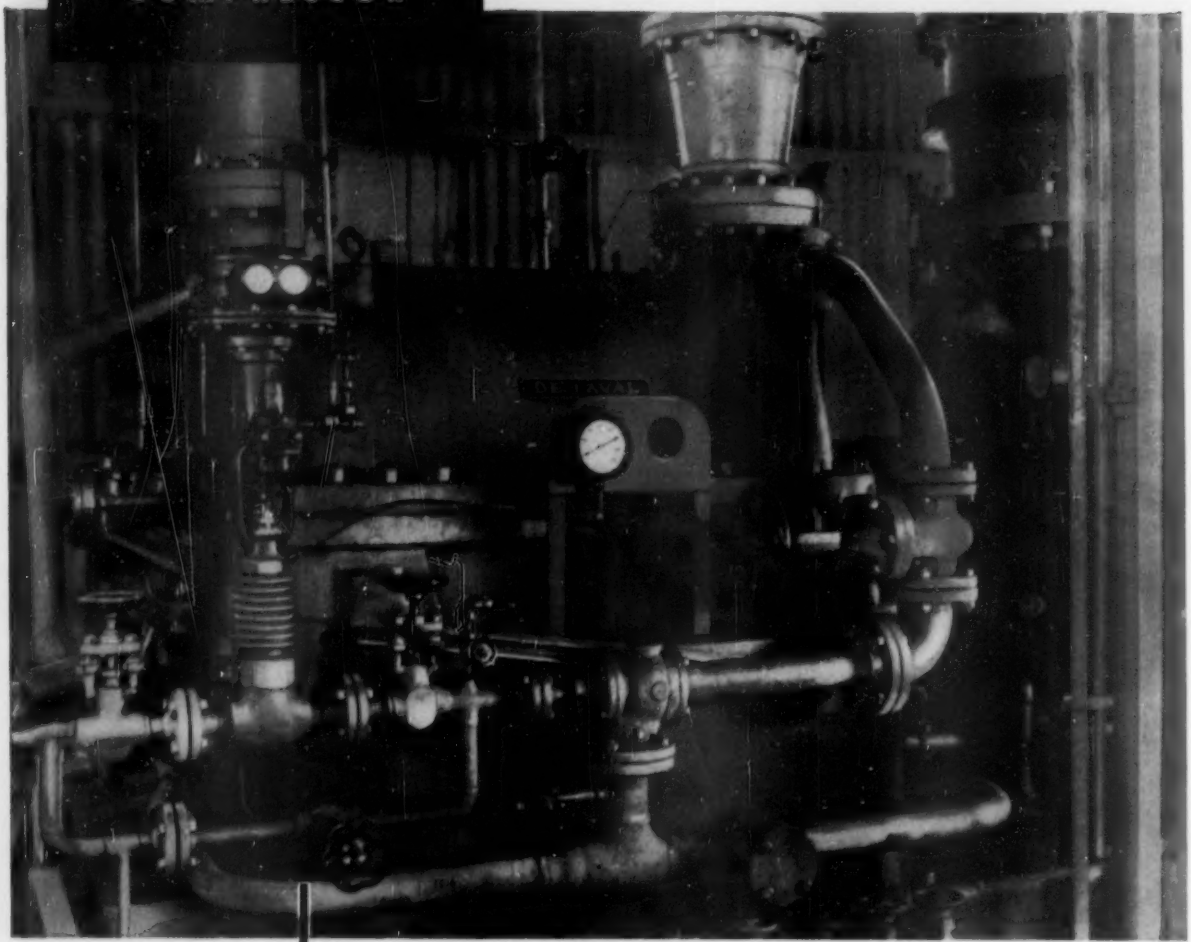
IN CANADA: CANADIAN PITTSBURGH INDUSTRIES LIMITED

● **Accelerated weathering tests** provide preliminary data quickly on the rate of fading and chalking, permitting reasonable accuracy in forecasting length of actual service.

● **Many types of special** Pittsburgh finishes have been used with uniform success on structures and facilities of all kinds by leading oil and gas companies in all parts of the world.

DE LAVAL
CENTRIFUGAL
COMPRESSOR

handles hydrocarbon gas in Sunray Oil refinery



Send for new Bulletin 0504

This De Laval 7-stage centrifugal gas compressor, installed at the Duncan, Oklahoma refinery of the Sunray Oil Company, handles a heavy hydrocarbon gas in a delayed coking process. The gas has a molecular weight of 31.5.

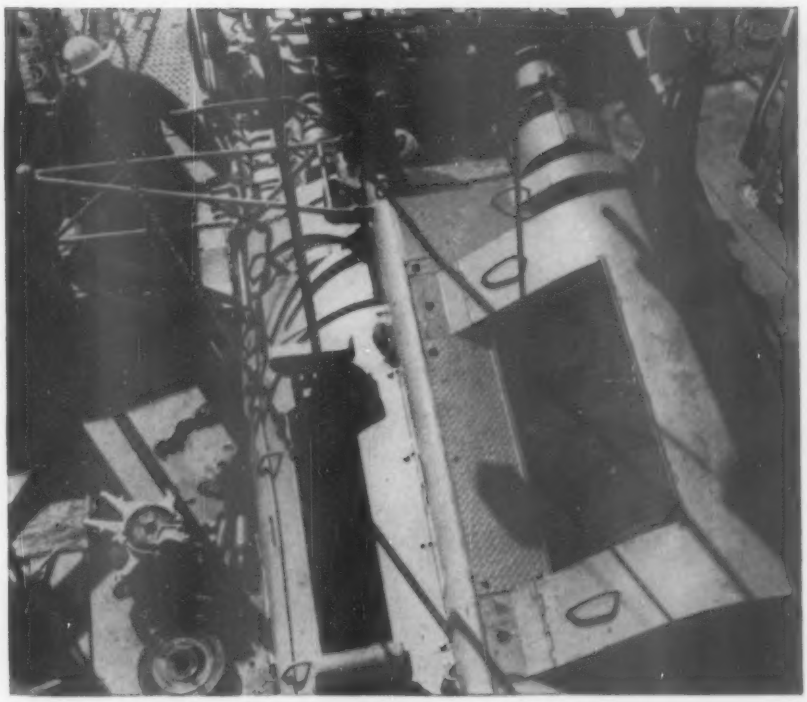
The De Laval centrifugal compressor is rated at 2840 inlet cfm; discharge pressure is 240 psia. The power required is 1350 bhp with compressor operating at 9900 rpm.

Sunray Oil is another refinery which has selected De Laval compressors for heavy-duty continuous service. Rugged, horizontally split casings, individually designed impellers, perfectly balanced rotors and externally mounted, cylindrically seated bearings are design features that assure optimum performance and long service.

DE LAVAL *Centrifugal Blowers*

DE LAVAL STEAM TURBINE COMPANY
810 Nottingham Way, Trenton 2, New Jersey

DL 387



2500 feet of Tiger Brand 1¼" 6 x 19 Excellay Preformed Monitor Improved Plow Steel IWRC wire rope are used on this rig. You can't beat this rope for long service.

"We've had very good luck with Tiger Brand Ropes"

says **Ed Meadows,** *Drilling Superintendent, Richardson & Stewart, McMullen County, Texas*

Ed Meadows, Drilling Superintendent, and A. R. "Swede" McCoy, Tool Pusher on Richardson & Stewart Rig No. 2 in McMullen County, Texas.

"We've tried a lot of different makes of wire rope, and American Tiger Brand gives as good or better service than any of them. We've had very good luck with Tiger Brand."

That statement is from Ed Meadows, and he ought to know what service to expect from wire rope. He's been using Tiger Brand for more than three years after experimenting with other makes.

Everybody has good luck when he standardizes on Tiger Brand—for top quality is built into the rope. Every process of manufacture is carefully controlled to assure long service life and low wire rope costs. Why not try Tiger Brand on your next job? Keep ton-mile records and prove it to yourself that Tiger Brand can lower your drilling costs.

Write for our ton-mile calculator.

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL
GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS AMERICAN TIGER BRAND WIRE ROPE

Excellay Preformed

USS

UNITED STATES STEEL

Engineered FOR THE Tough Jobs

....CONTINENTAL RED SEAL POWER

The new 4-wheel drive Oshkosh 50-50 ready-mixed concrete carrier is built to haul up to 5 cubic yards legally, with enough water for ready-mixed concrete operations. Its Continental Red Seal R6427 engine is cantilevered forward of the front wheels, distributing the load equally between the two axles, and making the unit conform to maximum load limits in most states . . . Continental F4162 engine driving the 4½ cu. yd. Rex Adjusta-Wate Moto-Mixer is mounted at rear of the machine, making possible the most efficient load distribution over all axles, for carrying maximum payload.

When it comes to tough jobs, the hauling of ready-mixed concrete ranks well toward the top of the list. It takes a real engine merely to move such a monster as this, to say nothing of lugging it over all sorts of terrain in order to spot the load. In the oil field, as elsewhere, Continentals have long been known for dependability. Their famous in-built stamina is earning them a place in more and more of today's heavy-duty equipment, not only in transportation but in industry and farming as well. Every Continental Red Seal is built for the job in which you find it—and backed by service and parts facilities coast to coast.

OPPORTUNITIES FOR ENGINEERS
Continental Motors and its subsidiaries have numerous openings for engineering personnel interested in challenging careers in gas turbine and reciprocating engine development. For information, address Engineering Personnel Dept., 12800 Kercheval Ave., Detroit 15, Mich.

Continental Motors Corporation

MUSKEGON • MICHIGAN

CONTINENTAL MOTORS ® Powerful as the Nation AMERICA'S STANDARD

6 EAST 45TH STREET, NEW YORK 17, NEW YORK • 6218 CEDAR SPRINGS ROAD, DALLAS 9, TEXAS • 3817 SOUTH SANTA FE AVENUE, LOS ANGELES 58, CALIFORNIA • 1252 OAKLEIGH DRIVE, EAST POINT (ATLANTA) GEORGIA

. . . and IBM electronics

With IBM electronic data processing you can take much of the guesswork out of oil exploration. With *all* the *facts* to guide drilling operations, the probability of drilling more producers is greater than was ever before possible.

In exploration, for example, seismograph, gravimetric and related data can be held in this electronic file for immediate processing or rework. Quickly, and with great accuracy, complicated problems in Ray Tracing, Residual Gravity and Second Derivation Calculations, Resistivity Computations, Optimum Shot Spacing, Correlation Studies . . . and other equally time-consuming formulas are solved. Results are printed in report form . . . or maintained on tapes or punched cards.

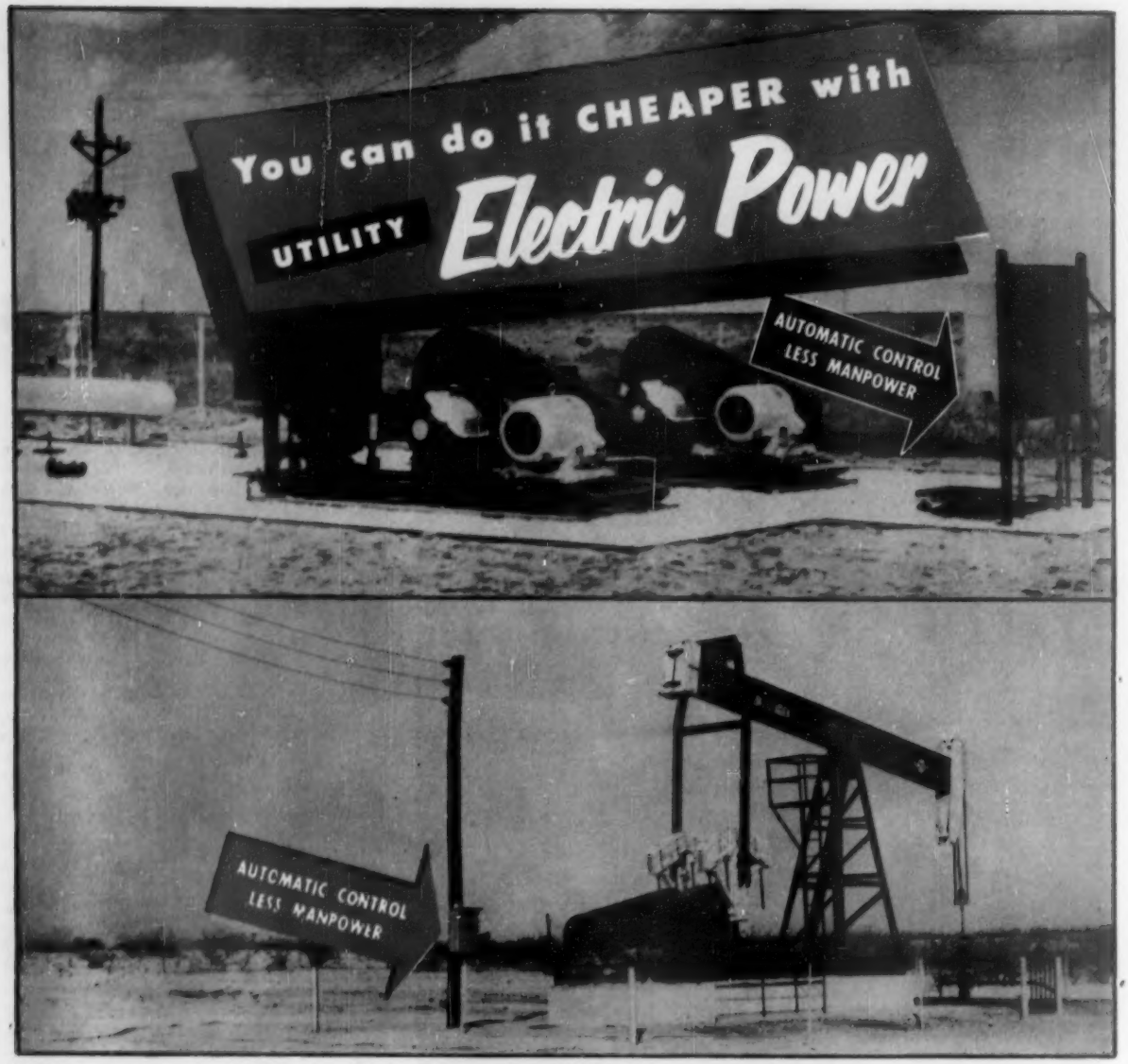
For field crews alone this represents tremendous man-hour savings. Data collected by seismograph crews can be relayed to the central computing unit, processed in relation to all previously gathered data, and new orders relayed quickly to the field to guide further explorations.

IBM electronic data processing systems, with their tremendous magnetic memories and the speed at which they absorb, file, compute, and print answers, are a thoroughly proven way to get essential data *fast!* In today's scramble for oil resources, this means higher profits, less wasted effort, and a gain of useful information heretofore highly desirable but too costly and time consuming to gather.

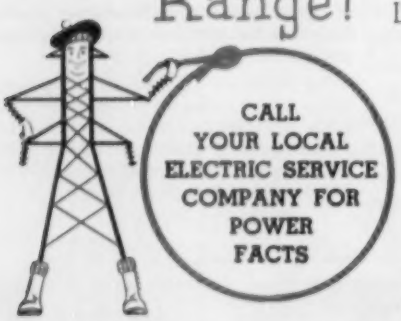
For the plain facts on IBM electronics in the Oil Industry, call your local IBM representative today, or write: PETROLEUM DEPARTMENT A56, International Business Machines Corp., 590 Madison Ave., New York 22, N. Y.

IBM DATA PROCESSING

MARKETING
EXPLORATION
PRODUCTION
REFINING
TRANSPORTATION



Electric Power is at Home on the Range!



Location and terrain are no handicaps — your Utility Electric Power Company is well equipped to give you the best power service — anywhere — any time. Pipeline pumping or production pumping, whatever the job, you can depend on Low Cost Utility Electric Power to do that job at lower installation, operating, maintenance and labor costs. There's no waste with Electric Power . . . just the right amount for the right job.

Petroleum Electric Power Association

P. O. BOX 2771, DALLAS, TEXAS

ORGANIZED IN THE INTEREST OF GREATER SERVICE TO THE PETROLEUM INDUSTRY

"Production increased 500%; lifting costs are extremely low"

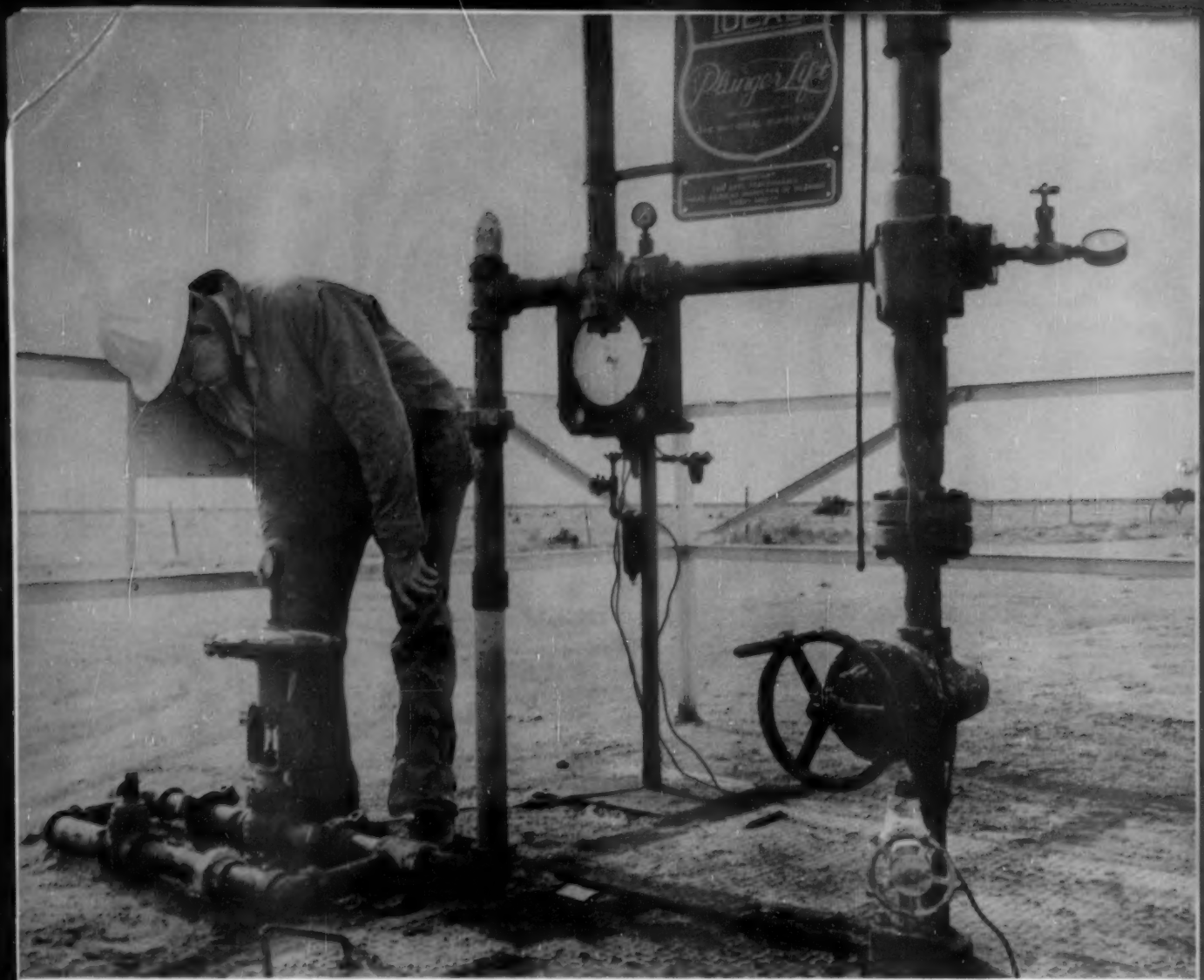
That's the report from one of our field engineers on a National Plunger Lift operating in Oklahoma. The unit was installed 5 years ago on a "problem well," then averaging 70 barrels per month production. Today, this well's 5-year average production record is 365 barrels per month! Almost 61 million cubic feet of gas also have been obtained during this time—at a value that alone paid for the initial cost of the Plunger Lift.

Not every National Plunger Lift shows such remarkable results, of course. But the list of satisfied users is growing rapidly, and the records are impressive.

For example: In a 5200 ft. Kansas well, a National Plunger Lift recently raised production 25% and eliminated paraffin deposits in the tubing. One doubled gas production for a California operator. Units in the Newcastle, Wyoming, area boosted production by an average of 30% and on some wells cut maintenance expenses from a high of $8,000 per year to an average of $250! Pleased with National Plunger Lift performance, two customers in Ohio and Michigan have recently ordered 5 more. And so it goes.

As you can see on the next two pages, the Plunger Lift is a specially-designed product applicable to certain types of wells. Most important, however, is the fact that it *dependably* meets the needs for which it is built, and helps producers lower their recovery costs. As such, it is typical of all quality equipment—drilling machinery as well as production units—bearing the National Blue Label.

THE
NATIONAL SUPPLY
COMPANY



NATIONAL'S PLUNGER LIFT® PAYS FOR ITSELF QUICKLY ON MANY TYPES OF WELLS

If you need a proved, low-cost system for prolonging production from wells with declining natural energy, don't overlook National's Plunger Lift. Simply designed, easy to install and economical to operate, it uses either formation or injected gas to step up recovery in—

- Weak-flowing wells, shallow or deep, with high gas-oil ratios and low P.I.
- Wells on gas lift, with low P.I.
- Wells too difficult to pump because of gas-locking
- Gas wells that load up with water

Adaptable to any wellhead, the National Plunger Lift also helps to overcome costly well conditions by preventing and removing paraffin deposits, preventing bottom-hole water accumulations, and reducing emulsion and scale deposits to a minimum.

With no added gas, the Plunger Lift operates at lower pressures than required for natural flowing wells. With added gas, it maintains low injection pressures, thereby getting the greatest percentage of a well's theoretical production by gas-lift methods.

These economical operating features of the Plunger Lift, along with its low initial and service costs, make it a unit that pays for itself quickly wherever you put it to work.

To learn specifically what a Plunger Lift can accomplish in your production operations, get in touch with your National Supply representative. Along with the material on the opposite page, he'll be glad to give you the whole, profitable story. See him soon.

ANALYSIS FORM
An advisory service is offered to producers who would like to know what Ideal Plunger Lift can accomplish in any particular well. You may use this form and either mail direct or submit it to your nearest National Supply Company representative. The data herein submitted will be analyzed and the results returned to you for further consideration.
ALL DATA SUBMITTED WILL BE HELD AS STRICTLY CONFIDENTIAL
NAME
TITLE
COMPANY
POST OFFICE
STATE
ADDRESS
LOCATION
WELL NUMBER
WELL AND FIELD DATA
IF ACTUAL DATA ARE UNKNOWN, PLEASE APPROXIMATE
STATIC BOTTOM HOLE PRESSURE
PRODUCTIVITY INDEX
AVERAGE CASING PRESSURE
AVERAGE TUBING PRESSURE
VOLUME OF FORMATION GAS
MCF DAY OR FARRENT GOR
IS EXTRA GAS AVAILABLE
VOLUME PER DAY
AVERAGE GAS PRESSURE AVAILABLE
MAXIMUM PRESSURE AVAILABLE
SEPARATOR OR FLOW LINE PRESSURE
AVERAGE DAILY PRODUCTION PAST 30 DAYS
BBL DAY
API GRAVITY
WATER CUT
SAND CUT
PARAFFINE
SIZE TUBING
SET AT
SIZE CASING
SIZE LINER
PRESENT METHOD OF PRODUCTION
CHOKE SIZE

A special advisory service

There is no guess-work involved in considering Plunger Lift for your well conditions. The first step taken is an application analysis based upon well and field data you supply. This advisory service insures that you know, **in advance**, what improvements you can expect through production with National Plunger Lift.

Naturally, there's no obligation for this special advisory service, or technical bulletins describing Plunger Lift systems. You can get Analysis Forms and literature at the nearest National Store, or from a National field representative. May we serve you soon?

NEW DUAL RELAY PLUNGER LIFT®!

National has a Dual Relay Plunger Lift for high P.I. wells and larger producers which are beyond the capacity of single plunger operation. Two plungers now can be run in the same string of tubing to accomplish faster cycling, at lower operating pressures and increased capacity.

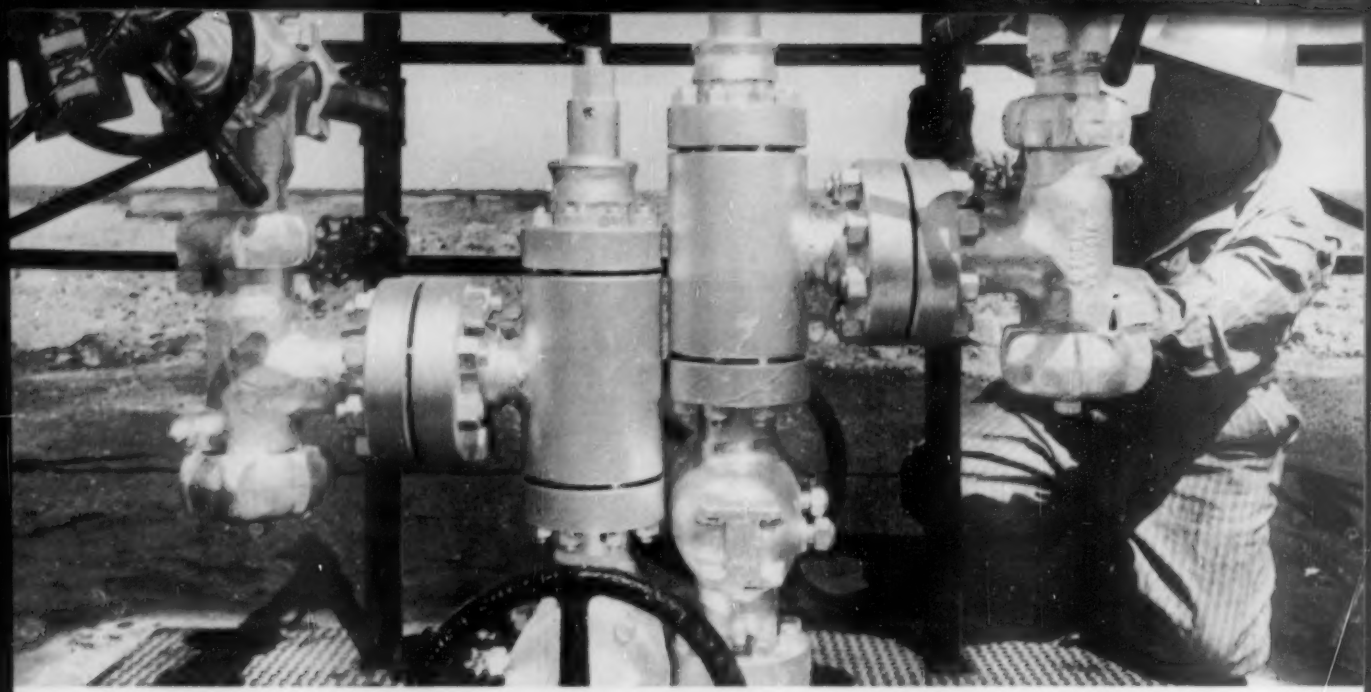
The bottom plunger lifts the oil from the well bottom to the halfway point, where the load is transferred to the top plunger and carried to the surface. The two plungers always travel in opposite directions, making contact only at the halfway point for load transfer and valve reversal. Simple controls are all located at the surface.

THE
NATIONAL SUPPLY
COMPANY

MAIN OFFICE: Two Gateway Center, Pittsburgh 22, Penna.
DIVISION OFFICES: Denver; Ft. Worth; Houston; Toledo; Tulsa; Torrance
CANADA: The National Supply Company, Ltd., 200 F. W. Clark Building, 709 Eighth Avenue, West, Calgary, Alberta
EXPORT: 600 Fifth Avenue, New York 20, N.Y., U.S.A.; City Wall House, Chiswell Street, London E. C. 1

NATIONAL BLUE OIL FIELD MACHINERY AND EQUIPMENT
SPANG STEEL PIPE AND ELECTRICAL CONDUIT

ON THE NEXT PAGE:
MORE NATIONAL
PRODUCTION EQUIPMENT



You get safe, economical production with NATIONAL Wellhead Equipment!

From the bonnet to the casing flange, every component part of a National Wellhead assembly is designed, built and tested for specific service application. The following main features of National Wellhead Equipment insure maximum performance with utmost safety—

- Ease of assembly—parts are self-locating and self-activating, no special tools are needed for installation.
- Maximum flexibility—interchangeable units afford a multitude of combinations to meet your specific requirements in size, capacity and type.
- Pre-tested safety—National's triple-sealed Pressure Pack design insures trouble-free performance and longer service life. Intensive testing procedures include special methods more severe than those specified by API standards.

You'll find National Wellhead Equipment readily available through all National Supply Stores—as well as complete advisory service on wellhead application problems. The complete line includes a wide variety of tubing hangers, bonnets, flanged and screwed fittings, valves, flow beans and specialty items to meet your every need. It will pay you to use this quality equipment—and the service that comes with it.

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NATIONAL BLUE OIL FIELD MACHINERY AND EQUIPMENT
SPANG STEEL PIPE AND ELECTRICAL CONDUIT

You get sound performance, too, from . . .

NATIONAL Pumping Units

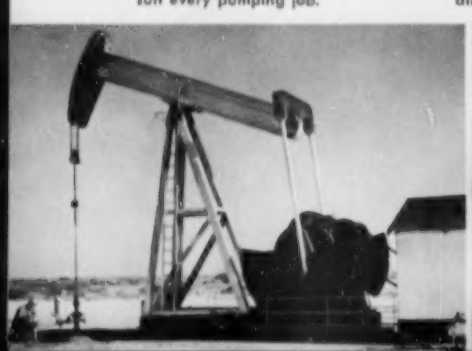
These pumping units are manufactured in 22 standard combinations, in the range of API rated beam loads from 3,200 to 32,400 lbs. There's a model to economically suit every pumping job.

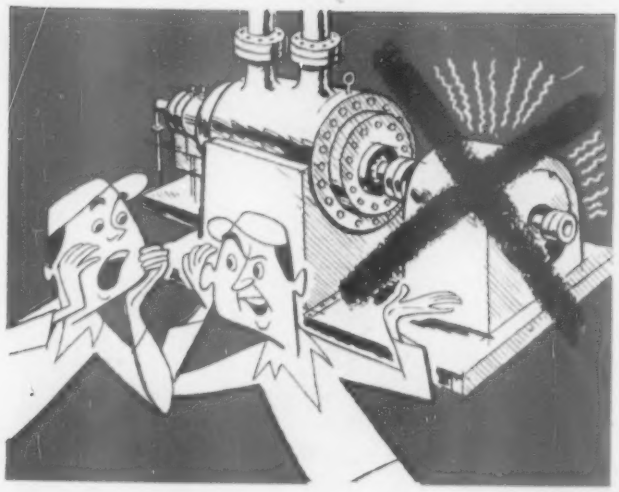
NATIONAL Triplex Pumps

These pumps provide maximum volume and injection pressures for today's waterflood projects. Available in several hp ratings for both corrosive and non-corrosive service, these National Pumps are also suited as power-oil source for subsurface hydraulic pumping, oil gathering and salt water disposal services.

NATIONAL Sucker Rods

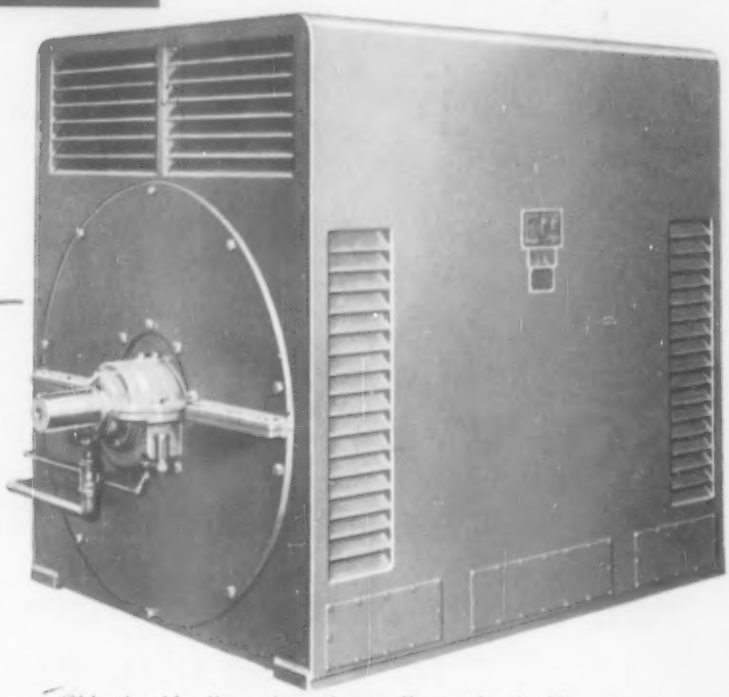
You get trouble-free service with National's precision-manufactured sucker rods. They're engineered for top resistance to shock, corrosion, fatigue and impulse loads. Top-quality National Sucker Rods are available in a range of grades for every well condition.





Eliminate This Sound "Barrier"

the NEW ELLIOTT *Quiet* 2-POLE MOTOR



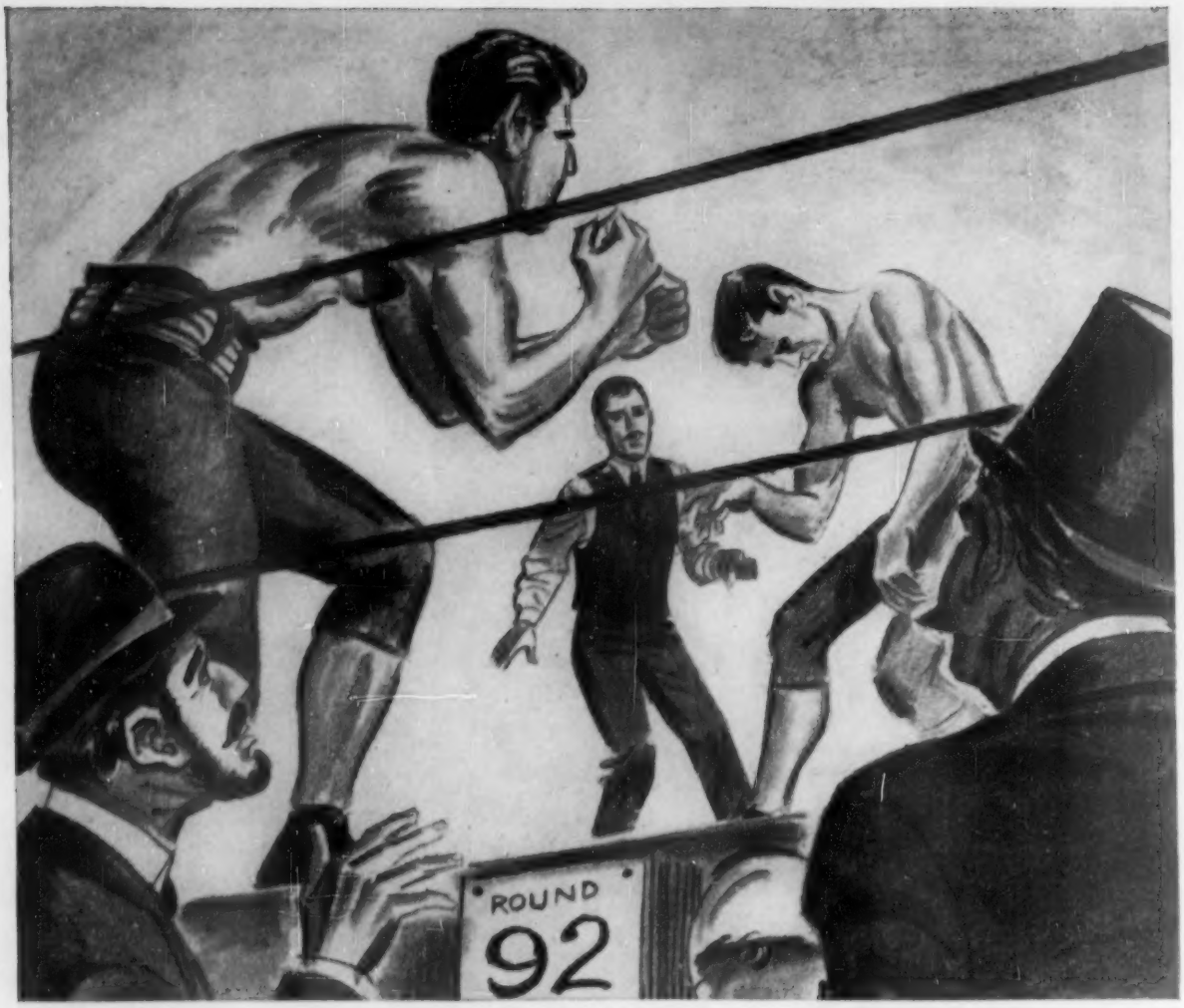
• Objectionable, distracting noise usually associated with large 2-pole motors, has been a "barrier" to operator comfort and efficiency and a hindrance to sound plant community relations. The new Elliott *Quiet* 2-pole motor reduces offensive noise with a design that minimizes and muffles the disturbing high pitch sound right at its source. The answer is found in many elements of this new motor—rotor, stator and even a special ventilating system that helps baffle and absorb the sound. Arrange now to "hear" this new Elliott motor. Check with your Elliott Representative or write Elliott Company, Ridgway Division, Ridgway, Pa.

Elliott FABRI-STEEL MOTORS AND GENERATORS

ELLIOTT Company

RS-4

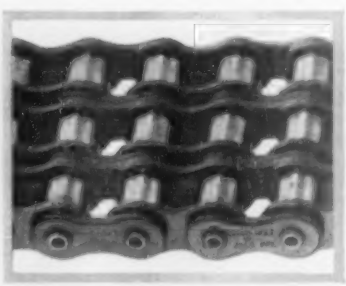
TURBINE-GENERATORS · TURBINES · MOTORS · GENERATORS · DEAERATING HEATERS · EJECTORS · CONDENSERS · COMPRESSORS · TURBOCHARGERS · TUBE CLEANERS · STRAINERS



You need extra strength to fight fatigue in roller chains, too...

Under the severe loads of oil field drilling service, ordinary roller chains may sometimes develop fatigue cracks around the pin holes in inner pin link plates. But, with Rex Roller Chains you can forget about this. These rugged, long-lasting chains have eliminated frequent premature chain failures.

Pin holes in the inner side plates of Rex Roller Chains have been tremendously strengthened by a special manufacturing process. It's one more cost-cutting, life-saving reason why you should investigate Rex Roller Chains for your rigs... there's no better chain made! For the complete story, see your supply store, your Rex® Field Sales Engineer, or write to CHAIN Belt Company, 4619 W. Greenfield Ave., Milwaukee 1, Wis., for your copy of Catalog No. 55-3.



CHAIN BELT COMPANY

MILWAUKEE 1, WISCONSIN

OIL FIELD OFFICES: DALLAS • HOUSTON • TULSA • MIDLAND • LOS ANGELES • NEW YORK

This is Why the Nash is the Most Simple Compressor

It's the Nash!

There are no mechanical complications in a Nash Compressor. A single moving element, a round rotor, with shrouded blades, forming a series of buckets, revolves freely in an elliptical casing containing any low viscosity liquid. This liquid, carried with the rotor, follows the elliptical contour of the casing.

The moving liquid therefore recedes from the rotor buckets at the wide part of the ellipse, permitting the buckets to fill with gas from the stationary Inlet Ports. As the casing narrows, the liquid is forced back into the rotor buckets, compressing the gas, and delivering it through the fixed Outlet Ports.

Nash Compressors produce 75 lbs pressure in a single stage, with capacities to 6 million cu. ft. per day in a single structure. Since compression is secured by an entirely different principle, gas pumping problems difficult with ordinary pumps are often handled easily in a Nash.

Nash simplicity means low maintenance cost, with original pump performance constant over long periods Data on these pumps sent immediately on request

No internal wearing parts.

No valves, pistons, or vanes.

No internal lubrication.

Low maintenance cost.

Saves floor space.

Desired delivery temperature automatically maintained.

Slugs of liquid entering pump will do no harm.

75 pounds in a single stage.

NASH ENGINEERING COMPANY

313 WILSON, SO. NORWALK, CONN.

for better economical casing perforating . . . Twin Jets fill the bill.
for better squeeze cementing . . . Four shots in a plane from 4-Way Jets.
Welex Perforating SPECIALISTS . . .
for every completion need
A jet perforator for every job . . . and every one developed by Welex to meet a specific need. All jets have been thoroughly tested and proved. When you call on Welex . . . you will get exactly the right type and size of jet that will give you maximum performance and better completions.
CALL WELEX AND BE SURE!!
for better open hole shooting . . . Maximum power Torpedo Jets.
for better permanent-type completions . . . Swing Jets for full power thru tubing.
for better jet casing perforating . . . A Perfo-Jet gun for every size of casing.

Welex
JET SERVICES, INC.

WELEX JET SERVICES, INC.

1400 E. Berry Street • Fort Worth, Texas

SALES OFFICES: Dallas, Duncan, Wichita

DIVISION OFFICES: Houston, Midland, Tulsa, Oklahoma City, Denver

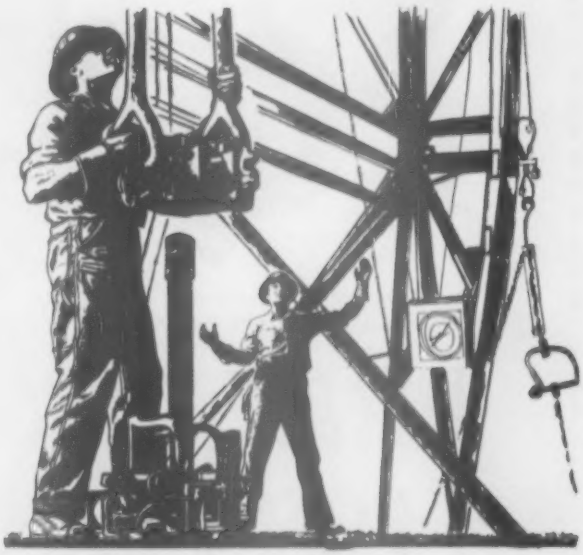
DISTRICT OFFICES: Abilene, Ardmore, Bartlesville, Beaumont, Corpus Christi, Falfurrias, Farmington, Fort Morgan, Great Bend, Hobbs, Houma, Houston, Lafayette, Lake Charles, Liberal, Odessa, Pampa, Pauls Valley, Plainville, San Angelo, Shawnee, Sherman, Snyder, Stillwater, Wichita Falls, Winfield.

Transmits Power *Smoother than Steam*

in Drilling, Servicing and Fracturing Rigs

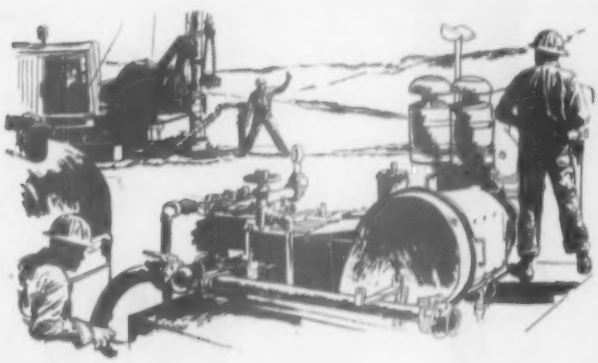
Faster Drilling with TORQMATIC DRIVES

Best way to speed round trips – and to make hole faster – is to equip your rig with an Allison Converter-Transmission team. It lets you pull a 5000-foot string in high, cuts rig maintenance, cushions and absorbs shock loads instead of transmitting them to other rig components.



Service Wells Better with TORQMATIC DRIVES

Shock-free, *smoother than steam* TORQMATIC power transmission takes it easy on well-tubing, lets servicing units do a faster job. One operator reports his TORQMATIC DRIVE "saves me $1.00 per foot of hole." Another reports he services wells 25% faster with TORQMATIC DRIVES.



Fracture Wells Faster with TORQMATIC DRIVES

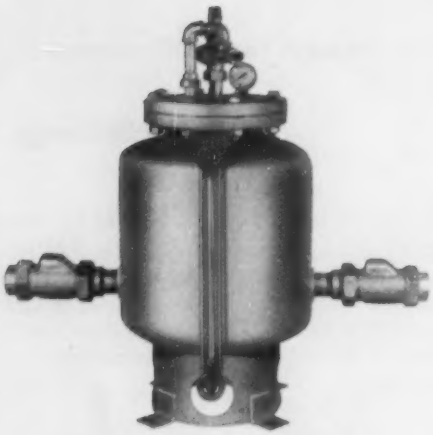
One big reason practically every fracturing company uses Allison TORQMATIC DRIVES is to get steadier pressure and higher sand-oil input into the well. And the ability of TORQMATIC DRIVES to quick-shift at full throttle ends the danger of sand-oil mix settling in the well.

If you'd build or buy better drilling, servicing or fracturing equipment – that will save you money on every well – specify Allison TORQMATIC Converters or TORQMATIC DRIVES. For full details write Allison Division of General Motors, Box 894R, Indianapolis 6, Indiana.

GM TORQMATIC *Allison* TORQMATIC DRIVES

GAGE VALVES

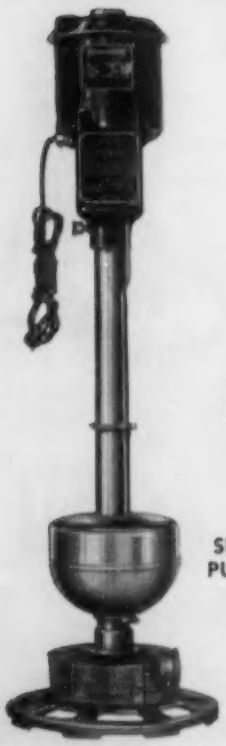
INJECTORS



CYCLING JET PUMPS

PENBERTHY PRODUCTS FOR PETROLEUM . . .

MEASURE • MIX • PUMP • WASH • EXHAUST • AGITATE • COMPRESS • ATOMIZE
CIRCULATE • AERATE • INJECT • CONDENSE • EXTRACT • AMONG OTHER USES



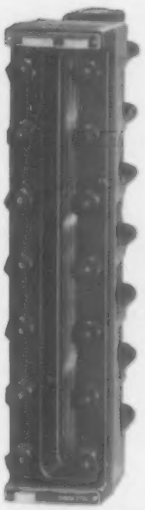
SUMP PUMPS

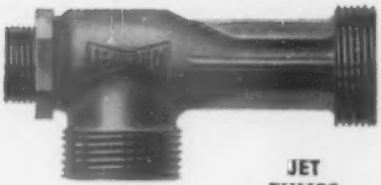
- Simplifying systems, saving time and money, guaranteeing accuracy— Penberthy products serve the petroleum industry directly and as components of equipment. Penberthy is equipped and staffed to engineer and produce dependable products. We'll be glad to send you catalogs and literature detailing our products and services. You are almost certain to find one or more ways we can contribute to your operations.

WATER HEATERS

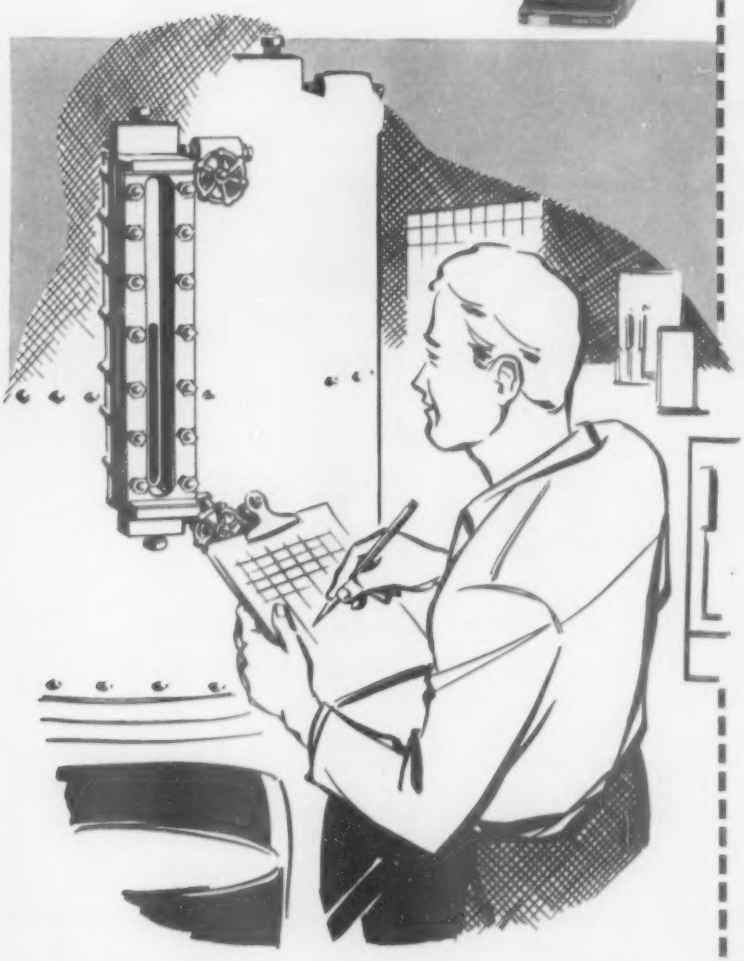
PENBERTHY
DIVISION OF BUFFALO
1242 Holden Avenue

LIQUID LEVEL GAGES





JET
PUMPS
(Ejectors, Eductors,
Exhausters, Syphons)



INJECTOR CO.

ECLIPSE CORPORATION

Detroit 2, Michigan

Penberthy Gages feature, as standard, the exclusive "Raised Face" to facilitate cleaning and replacement . . . assuring perfect alignment of frame with glass and gasket. They are accurate, rugged and reliable. Available in standard or special designs, sizes and materials. The line includes: Reflex, Transparent, High Pressure, Frost-Free, Heating Tube and Heating Chamber, Welding Pad, Large Chamber and Inclined Gages as well as Explosion-Proof Illuminators.

Penberthy Gage Valves, with exclusive "Floating Shank", save 50% and more on installation costs alone . . . eliminate dangerous strains common to forced installations. The line includes: Tubular and Threaded gage valves. Jacketed gage valves, Instrument valves. Wire glass, plate glass and sheet metal guard protectors.

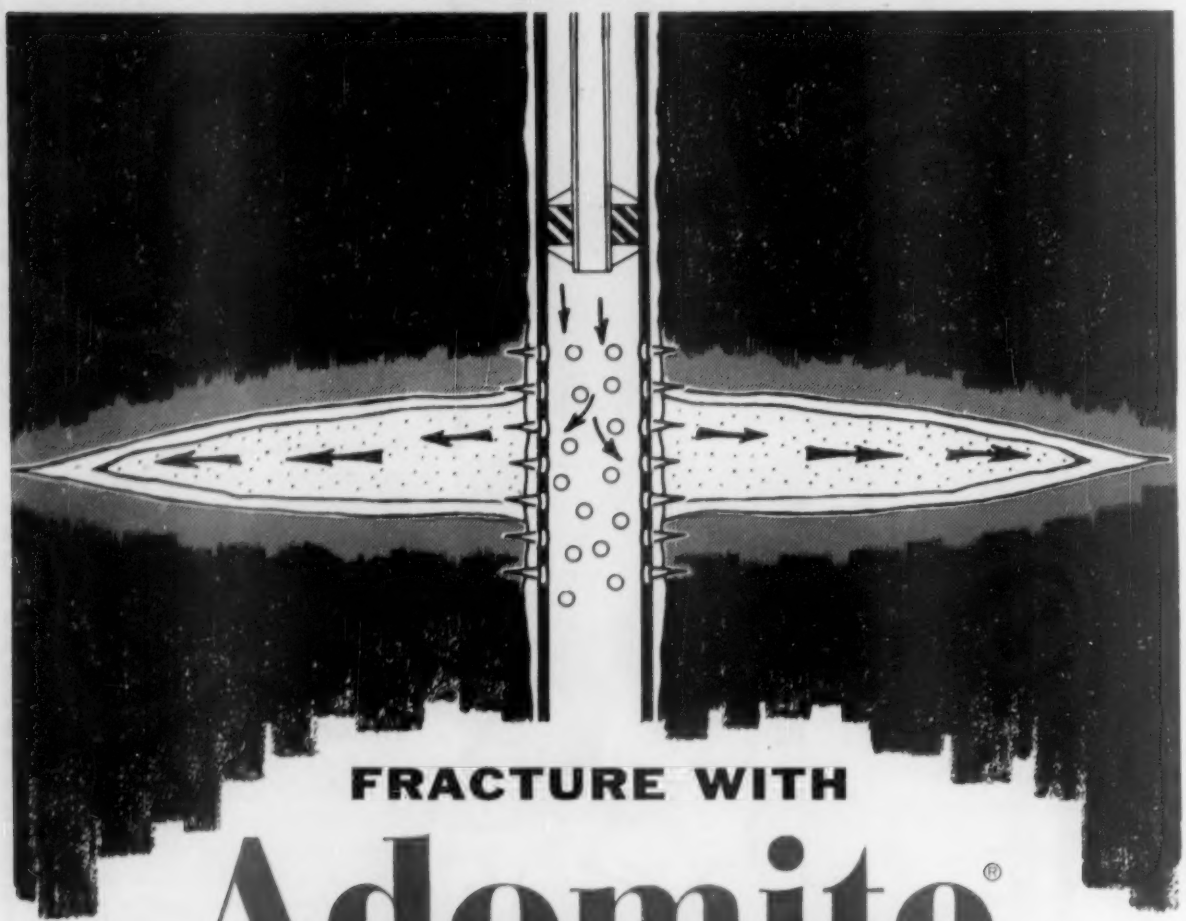
Penberthy Ejectors are available in bronze, iron, stainless steel, plastic and other materials . . . in standard or made-to-order designs. They provide a simple, efficient means of handling liquids, gases, solids in suspension and even dry materials. Nothing to get out of order, low cost, small size, practically noiseless.

Penberthy Cycling Jet Pumps are gas, steam, or air operated with a minimum of moving parts. Superior for injecting chemicals into vessels or lines, transferring fluids and for pumping operations in hazardous locations.

Penberthy Water Heaters utilize steam to heat water or any other liquid to any temperature up to 212°F. High grade bronze construction. Compact. Efficient.

Penberthy Sump Pumps are available in a variety of sizes and capacities, bronze construction, automatic-electric, standard, submersible and explosion-proof.

CUT FLUID LOSS TO A MINIMUM



FRACTURE WITH

Adomite®

Specify the fluid-loss control agent proven profitable in thousands of successful field treatments

Only Adomite gives you all these advantages — so effectively	Larger fracturing per volume of treatment—or the same size fracture with a lesser volume of fracturing oil.	Acceptance of fracturing fluid by pipeline companies —fracturing oils made from lease crude and Adomite are completely acceptable to pipelines.	Fewer sand-outs. Adomite prevents loss of fluid into the rock matrix, preventing buildup of sand concentration in the fracture.
Lower transportation costs. The fracturing oil costs you nothing when you use your own lease crudes.	Decreased friction losses. The low viscosity of Adomite-treated crudes or gelled crudes permits the use of less pumping equipment than viscous refinery residuals.	Compatibility of fracturing fluid with reservoir oils. Since Adomite is used with lease crudes, the fracturing fluid is fully compatible.	Fluid loss control with one additive. Adomite is all you need to control fluid loss of kerosene, crudes, gelled crudes or refinery residuals.

© 1956, Continental Oil Company

BE SURE TO TELL YOUR SERVICE COMPANY TO USE ADOMITE

Adomite — developed and manufactured by Continental Oil Company

Adomite® — trade mark, Continental Oil Company

Four Le Roi L3460 engines in a pipeline station owned by a major oil company. Three of them have been in continuous operation for six years. None have undergone a major overhaul.

Power-Packed Pipeline Station

. . . uses Le Roi L3460's to provide plenty of low-cost pumping power

Le Roi's L3460 with 600 max. hp. and its bigger brother, the L4000 with 655 max. hp., are ideal for pipeline service on many counts. Here's why:

Plenty of power with good fuel economy—These engines develop 600 and 655 max. hp. with rock-bottom fuel consumption, and can be run on natural gas, gasoline, or butane. Advanced design manifolding, low friction bearings, and low power loss to accessories, all contribute to unusual operating economy.

Long engine life—Perhaps the best proof of this statement is found in the trouble-free performance experienced by users in installations like the one shown above. Basically the L3460 and L4000 are compact, high-output engines designed with short stroke to give you greater horsepower and speed, without compromising engine life. And that's exactly what they do for you.

More comfortable operating conditions—Water-cooled exhaust manifold cuts down engine heat in operating areas, yet provides fast engine warm-up. The smooth, clean lines of these engines prevent dirt from collecting —that's why they are so easy to keep clean.

Compact V-12 design packs a lot of horsepower in a small space—to give you more horsepower per dollar. This, plus vibrationless performance, reduces foundation costs, simplifies installation.

We think that if you see an L3460 or L4000 in operation you'll agree that they provide the answer to low-cost pumping power. Have your supply house or Le Roi distributor show you one at work. Bulletins are available upon request—just write us.

P-140

LE ROI *Division of Westinghouse Air Brake Co.*

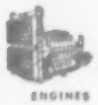
Milwaukee 1, Wisconsin

PORTABLE AIR COMPRESSORS

TRACTAIR

STATIONARY AIR COMPRESSORS

AIR TOOLS


ENGINES

Visibility unlimited . . .

DOW

Airplane patrol of pipelines calls for vegetation control with Dow products.

DOW WEED KILLERS SIMPLIFY AIR PATROL *and* MAINTENANCE

Keep vital oil areas vegetation free. The very best vegetation control at the very lowest cost—that's what you're looking for. And that's what you get with Dow weed, brush and grass killers. These products help you keep both your vegetation control problems and your costs under control.

When you keep vegetation from growing over and around pipelines, you simplify both airplane patrol and ground crew maintenance of these essential oil arteries. Where fire prevention is vital—you can depend on specific Dow chemicals doing specific jobs to clear and maintain extensive areas at a measurable saving per acre.

Write us for technical information and assistance on the use of Esteron® 245, Esteron Brush Killer, Esteron Ten-Ten*, 2, 4-Dow* Weed Killer, Formula 40—also Radapon* for grass control and Baron*, a new vegetation control product for extended control of both grasses and broad-leaved weeds. THE DOW CHEMICAL COMPANY, Agricultural Chemical Sales Department, Midland, Michigan.

*Trademark of The Dow Chemical Company

Fire prevention and good housekeeping on premises call for Dow vegetation control chemicals.

you can depend on DOW CHEMICALS

DOW

Transcontinental pipelines are among the many places where Cathodic Protection and Anaconda Type CP Cable are used to check corrosion.

Cable that helps make the pipeline a good neighbor

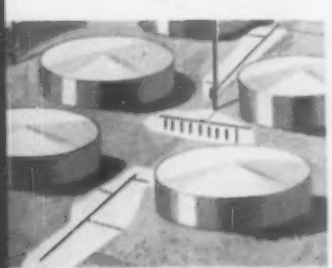
To make cathodic protection systems more economical and effective – to help pipeline and oil companies check costly corrosion, stop leaks, make pipelines good neighbors – Anaconda offers a special Type CP Cable that *lasts far longer* on the job than ordinary cable.

High-grade polyethylene insulation and tough Densheath® (PVC) jacket offer high resistance to electroendosmosis†, as well as high resistance to oil, moisture, and most acids, alkalies and chemicals found in corrosive areas. And rugged Densheath withstands toughest abrasion, moisture and weathering.

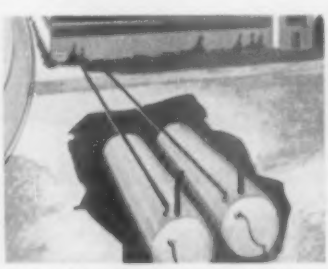
To order, or for more information—call the Man from Anaconda. Or write: Anaconda Wire & Cable Company, 25 Broadway, New York 4, N.Y.

†Cable failure on direct current in wet locations ®Reg. U.S. Pat. Office

WHERE ANACONDA TYPE CP CABLE AND CATHODIC PROTECTION CUT CORROSION COSTS



Tank farms



Underground storage tanks

Pipelines

Oil refineries

ASK THE MAN FROM **ANACONDA**

FOR **CATHODIC PROTECTION CABLE**

". . . operates more economically and cuts the hole faster . . . we are happy to recommend them. . ."

W. R. Brunson
Drilling Superintendent

DEPENDABLE ! LOWER MAINTENANCE !
INCREASED PROFITS !

WHELAND HP-18000

7¾" x 18" DUPLEX POWER SLUSH PUMP

750 HORSEPOWER

Nominal Input at 60 RPM
1322 lbs. mud pressure with 7¾" liner
2700 lbs. mud pressure with 5½" liner
Weight 36,377 lbs.
Compact—Easily Moved in One Piece!

DILLARD & WALTERMIRE DRILLING COMPANY
DRILLING CONTRACTORS
11TH FLOOR STALEY BUILDING
WICHITA FALLS, TEXAS

March 8, 1956

Mr. Gordon P. Street, President
The Wheland Company
Chattanooga, Tennessee

Dear Mr. Street:

We bought our HP-18000 Wheland Pump because we believe it to be the best. It operates more economically and cuts the hole faster than any other pump of this size that we have ever used and believe that it is thoroughly field proven.

This being our third Wheland Pump, we are happy to recommend them.

Dillard & Waltermire's operations are in Oklahoma, Southern La., Gulf Coast, West Texas and North Texas areas.

Yours very truly,

W. R. Brunson
Drilling Superintendent

Pictured left to right: Mr. Joe Don Carlos, Mr. W. R. Brunson and Mr. O. L. Scott

WRITE FOR DETAILED BULLETIN

WHELAND

ROTARY DRILLING MACHINERY

THE WHELAND COMPANY

CHATTANOOGA, TENNESSEE, U.S.A.

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CROWN BLOCKS • TRAVELING BLOCKS • SWIVELS

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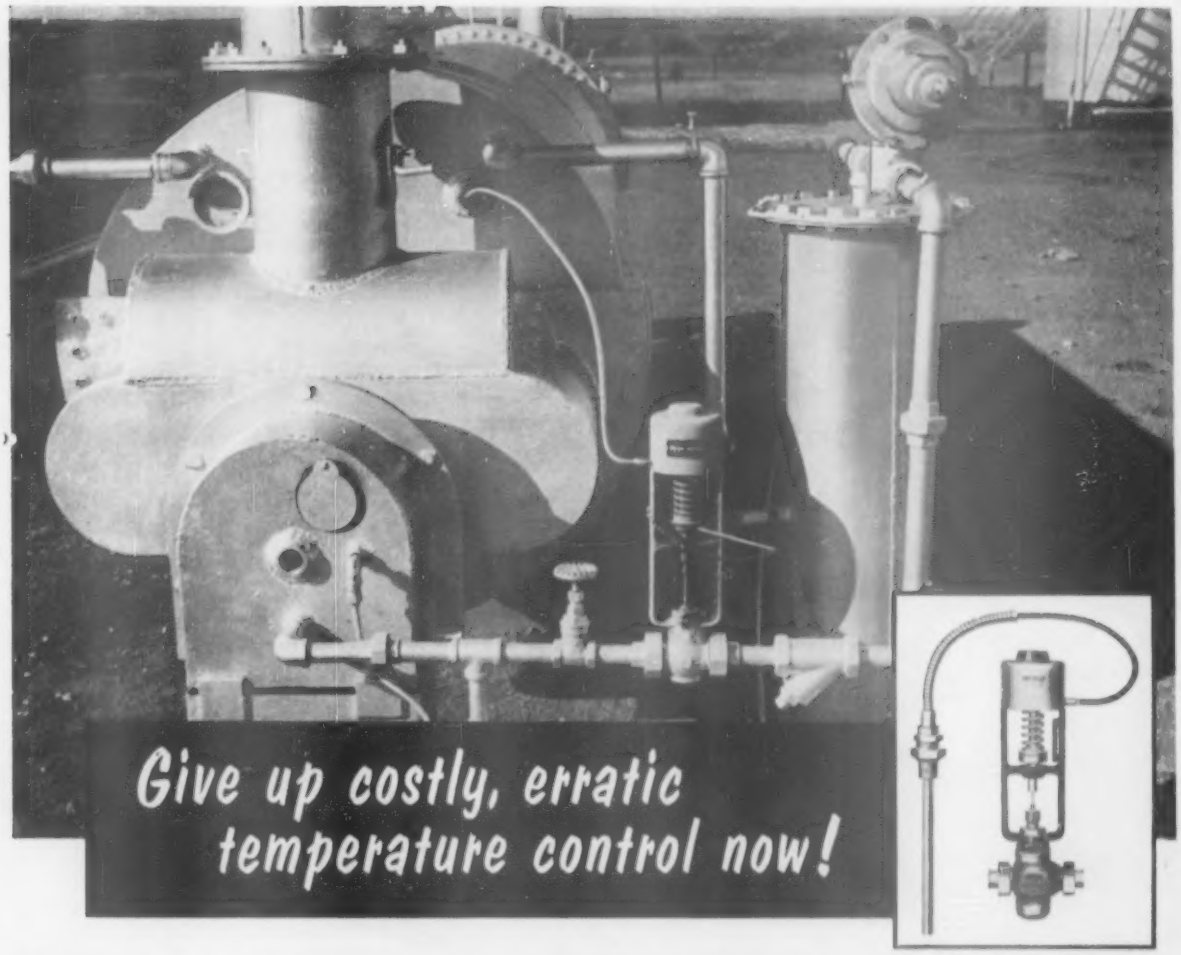
EXPORT DISTRIBUTORS: LUCEY EXPORT CORPORATION—233 Broadway, New York 7, New York—Broad Street House, London, E. C. 2, England.



INSTALL 'AMERICAN' TEMPERATURE REGULATORS

Oil heaters and treaters . . . water heaters . . . diesel water jackets . . . dryers . . . ovens . . . plating tanks . . . washers . . . feedwater systems . . . air-compressor after coolers. Equipment of all kinds in all kinds of industries is seldom kept at required temperatures *when operated manually*. Result: a lot of money wasted every day.

Eliminate costly, erratic manual control—now! Get reliable overheat protection. American Temperature Regulators do a far better job than even the most skilled operators. They are self-operated, automatic—constantly maintain temperatures within required limits. Greater product uniformity is assured. Fuel and manpower are saved. Users find these sturdy, powerful regulators often pay back their cost 3 to 6 times a year. Many serve dependably 10 to 25 years!

Boost efficiency and economy wherever accurate temperature control is an everyday necessity. American Temperature Regulators are sensitive and responsive. Installation is simple. No compressed air or electricity needed. Temperature adjustment and repeat setting are easy. Sizes range from ¼" to 4". Get complete details. Write for Bulletin 112C.

YOUR INDUSTRIAL SUPPLY DISTRIBUTOR is as close as your telephone. You can depend on him for experienced counsel, money-saving service and prompt delivery from local stocks.

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A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Oklahoma.* AIRCRAFT CONTROL PRODUCTS, *Danbury & Stratford, Conn. and Inglewood, Calif.* "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.*

What's in prospect for petroleum?

While not as much in evidence here as the gasoline, there are many other important products of petroleum in this picture. Today, few processes are as prolific as petroleum refining. In addition to new high-octane fuels and improved lubricants, many new plastics, paints, dyestuffs, detergents, and drugs owe their origin to a refinery. And, as the list grows longer, so grow the requirements of one of the nation's largest chemical-consuming industries.

To anticipate and provide for the diverse chemical requirements of the petroleum industry, Olin Mathieson offers a unique program of *coordinated planning and production*. This assures refiners and processors of the availability of chemical raw materials regardless of changing market conditions, new product developments, or requirements for plant expansions.

At present, a growing number of chemical consumers are coordinating their planning and production with Olin Mathieson . . . America's prime producer of basic industrial chemicals. Olin Mathieson's long experience and familiarity with the broad market picture can prove invaluable in *your* planning. Why not consult with us . . . now?

MATHIESON CHEMICALS

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INDUSTRIAL CHEMICALS DIVISION • BALTIMORE 3, MD.

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MATHIESON

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ORGANIC CHEMICALS: Ethylene Oxide • Ethylene Glycols • Polyethylene Glycols • Glycol Ether Solvents • Ethylene Dichloride • Dichloroethylether • Formaldehyde Methanol • Sodium Methylate • Hexamine • Ethylene Diamine • Polyamines • Ethanolamines • Trichlorobenzene • Polychlorobenzene • Trichlorophenol

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is the new-strength wire in Roebling's

Royal Blue

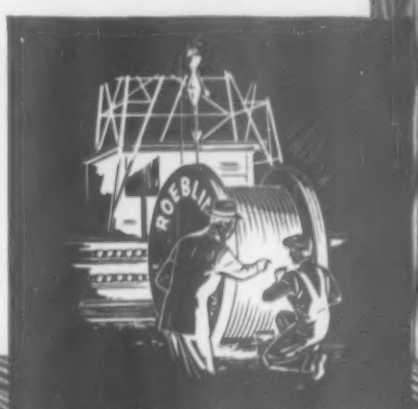
WIRE 1105 ROPE

AS SIZES and constructions go, Royal Blue is like the ropes you have used until now... but the likeness ends there.

Royal Blue is made of Roebling's new 1105 wire, the strongest, toughest wire developed up to now for use in any wire rope.

Royal Blue Wire Rope is as enduring as the wire from which it is made.

Write us for full facts on Royal Blue Wire Rope, or contact your Roebling distributor.



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NOW... a compact 75-200 bhp

FEATURES

BALANCED/OPPOSED COMPRESSOR DESIGN
Virtually vibrationless . . . a couple of yards of concrete will easily level it. Perfect for barge or truck mounting.

DIRECT CONNECTED
Eliminates belts or gear drives. Reduces skid size, housing costs. Simple rubber block couplings.

ONE PIECE SKID
Simple to install, move or shelter . . . only 7' 3" x 15', rigid heavy "I" beam construction.

TWO STAGE
For maximum efficiency and thru-put.

CONSERVATIVE PISTON SPEED
Lower than on most Clark stationary compressors, assures long cylinder life.

HEAVY DUTY RADIATOR
Straight finned tubes. Easy to inspect or clean, inside or out. Provides intercooling and cylinder jacket cooling.

FACTORY ASSEMBLED AND TESTED
No field assembly. Shipped as a complete unit.

STANDARD ENGINE DESIGN
Five makes of proved engine designs available.

APPLICATIONS
Use it for gas lifting, gas gathering, gas boosting, pipeline testing, recycle plant feeders, other field services.

Packaged Compressor

CFA now on tour
—in Oklahoma, Kansas, Colorado, Texas and Louisiana.
Watch your newspaper for date and location of demonstration.

Designed by Clark for gas lifting or gathering

You asked for this field compressor—as rugged, compact and perfectly balanced as the famed "Midget Angle" but of half the horsepower.

Now you have it, in the new Clark Model CFA. Rated at 75-200 bhp, this packaged compressor station is ideal for gas lifting or gas gathering of from one to a dozen wells. This is particularly true when well spacing is wide and multiple sands are being worked.

The CFA uses a new specially designed 5" stroke balanced/opposed compressor directly connected to a standard design gas engine. The compressor and engine, together with a heavy duty radiator, scrubber, etc., are mounted on a rugged steel skid.

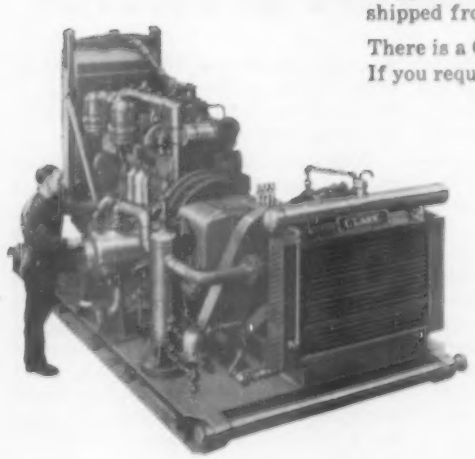
The CFA is virtually vibrationless in operation because of its balanced/opposed action. In most cases the small amount of concrete used to level the unit will provide ample support.

Operating at engine speed eliminates the need for cumbersome belt and gear drives. The resulting compactness permits mounting the complete unit on a skid measuring only 7′ 3″ x 15′.

Easily and speedily transported on an average size truck, this new field compressor can also be operated on truck or floating barge. The compact design minimizes costs if a shelter is required.

You have no field assembly problems. The CFA is factory assembled, tested and shipped as a complete unit. Because of standardization the CFA can be shipped from stock in most instances.

There is a Clark CFA specialist in your area to give you all the facts. If you require greater horsepower, ask him about the Clark HMA and HMAB.



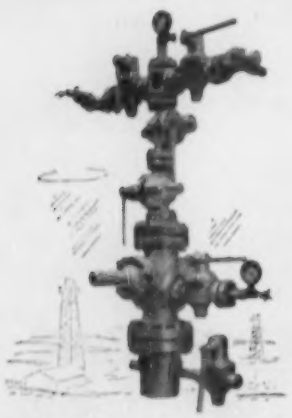
CLARK BROS. CO., OLEAN, N. Y.
ONE OF THE DRESSER INDUSTRIES
Offices in Principal Cities Throughout the World

CLARK®

Packaged Compressors

Goetze V-Tite Gasket being installed on flange of new Space Saver Blowout Preventer, designed and manufactured by Cameron Iron Works, Inc., Houston, Texas.

Goetze Gaskets safeguard critical points under severe pressures



Christmas Tree made by Cameron Iron Works, Inc., is equipped with Goetze V-Tite gaskets to provide safe, tight sealing for every joint.

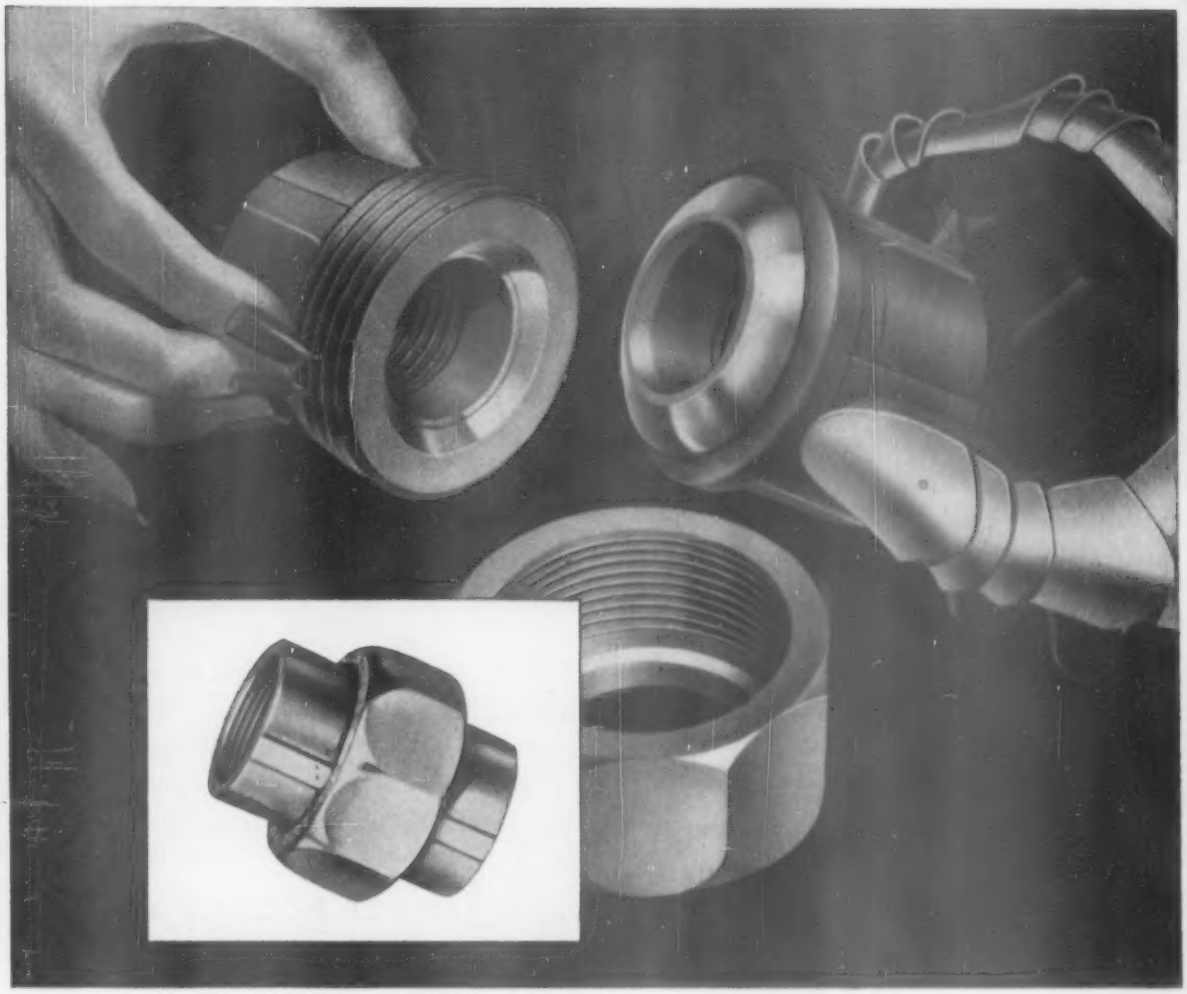
The new "Space Saver" Blowout Preventer made by Cameron Iron Works, Inc., of Houston, Texas, weighs only half as much as earlier equipment and takes only one-half the space. This improved design permits rig platforms to be smaller, makes possible savings on handling and materials.

For this new equipment Cameron chose Goetze V-Tite Gaskets to do the critical job of sealing Ring-Joint flanges. These precision-made gaskets withstand the high pressures encountered in oil and gas production. Goetze V-Tite Gaskets are fabricated to extremely close tolerances to secure perfect matching of rings with flange joints. They are carefully heat-treated to keep hardness below the maximum allowable. This assures proper flow of the gasket without damage to flange surfaces and reduces the necessity for undue bolt stresses.

Both standard cross-sectional shapes, the oval (Style 950) and octagonal (Style 951), seal tightly at low bolt stresses. Made to ASA-API standards, they are supplied in metals and alloys offering maximum resistance to service and temperature conditions. In addition to the ASA-API sizes, special sizes ranging from one inch to seven feet pitch diameter are available. Catalog PK-35A gives details, sizes and engineering data. Write for it to Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay St., Toronto 1, Ontario.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville GOETZE GASKETS



What a *difference* 150 Brinell makes!

Here's what makes the big difference! *The male seat of the new Rockwood Union #603 is specially treated to make it 150 Brinell harder than the female seat.* That means no galling in make up — longer life for the joint.

This hardness differential gives you superior performance — even under tough working conditions. Each part of the Rockwood Union #603 is interchangeable. Both seats are made of corrosion-resistant AISI molychrome steel, forged in place and bonded-locked under 100,000 and 400,000 pound pressure.

But the difference doesn't stop there! Exclusive "Rockwoodizing" protects entire Union, including threads, against corrosion.

This remarkable Union offers you all these features. You can't ask for anything better.

For complete facts, mail coupon now.

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Engineers Water . . . to Cut Fire Losses

Distributors in all Principal Industrial Areas

ROCKWOOD

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Please send me prices and further data on the new Rockwood Union #603. I would also like the name of the nearest Rockwood distributor.

Name.....

Title.....

Company.....

City.....

Zone.... State.....

Your ONE-STOP store for all Rubber Products for any Oil Field job

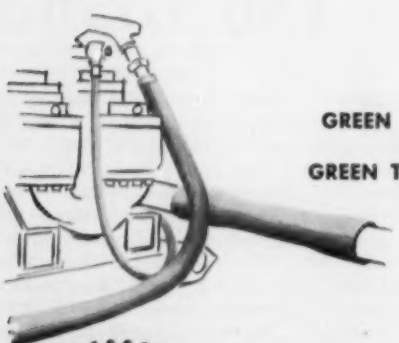
Everything — yes, EVERYTHING — needed in rubber goods for any job is available at your Continental Store.

Also, this money-saving convenience of one-stop service assures unsurpassed quality... products of New York Belting and Packing Company, America's oldest manufacturers of industrial rubber goods.

That's an unbeatable combination... under one roof a complete quality line for every need!

GREEN TRIANGLE ROTARY HOSE

...the hose with maximum durability and flexibility that has proved performance under the most demanding conditions. There's a Green Triangle Hose for every possible drilling pressure.



GREEN TRIANGLE SUCTION HOSE

GREEN TRIANGLE DISCHARGE HOSE

GREAT SEAL OIL FIELD UTILITY HOSE

NEW YORK BELTING & PACKING CO • Founded 1846

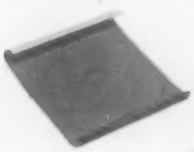
The New York Belting & Packing Company, America's Oldest Manufacturer of Mechanical Rubber Goods, is Represented Exclusively in the Oil Country by Continental Supply Company.

The Petroleum Industry — Since 1859 Helping Make America Great

TEST SPECIAL V-BELTS

The only V-belts engineered, manufactured and marketed exclusively for oil field use! Test Special V-Belts for every application are stocked, in matched sets, by your Continental Store.

17020 SUCTION AND DISCHARGE HOSE



GREAT SEAL PACKINGS

GREAT SEAL BUTANE HOSE

WASHDOWN HOSE

HY TEST BLOW-OUT PREVENTER HOSE

CONTINENTAL SUPPLY COMPANY

A Division of The Youngstown Sheet and Tube Company
General Offices: DALLAS, TEXAS

Representatives in All Principal Oil Fields of the World

CONTINENTAL

SERVING THE OIL AND GAS INDUSTRIES

ON REFINERY FUEL GAS SERVICE AND MANY OTHER PETROLEUM APPLICATIONS

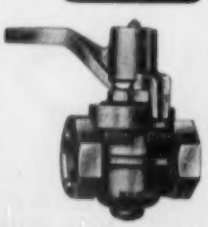
DeZURIK
PLUG VALVES

offer so many advantages on critical petroleum services. They open easily . . . just a quarter-turn of the handle. And they DON'T LEAK on gas or liquid services.

EXCLUSIVE
ECCENTRIC ACTION

accounts for the remarkable performance of DeZurik Valves. The eccentric-shaped, resilient-faced plug swings shut without friction . . . closes on the eccentric-raised seat, sealing tight despite scale, dirt or other solids in the line.

IN THE FIELD, OR IN THE REFINERY, DeZURIK VALVES reduce maintenance, increase efficiency! Write for details. Representatives in all principal cities.



DeZURIK
SHOWER COMPANY
SARTELL, MINNESOTA

They Say—

Of Business and Morals

"The oil industry has repeatedly demonstrated its ability to solve the problems created by changing times. In the last 40 years, for instance, the industry successfullly handled an expansion of 550 per cent.

"Perhaps the most important single reason for this success in the past, I believe, was the capacity of certain individuals in the industry to think creatively.

"Creative thinking isn't a mysterious process beyond the range of the average man. It is, rather, a frame of mind, a process of thought. It's an ability to think straight, to separate the important from the trivial, to differentiate between fact and fiction. It combines a good regard for past experience without unduly venerating it. It involves a receptiveness to ideas, regardless of source.

"Finally, it implies a character able to judge whether a decision reached is a morally sound one because, among other things, an unsound moral decision is also an unsound business decision."

J. A Miller, general manager of marketing, Esso Standard Oil Co., in address before the Virginia Oil Men's Association.

Squeeze on Contractors

". . . Practically every major cost borne by the contractor has risen consistently since World War II . . . In all, rotary drilling costs in 1955 were 97 per cent higher than in 1941. Yet, the per foot price tab passed on to the industry was 4 per cent lower . . . This reduction in unit cost in the face of rising total costs is a great tribute to the contracting industry."

A. W. Thompson of A. W. Thompson, Inc., Houston, vice president for production of A.P.I., in address before Mid-Continent district meeting of A.P.I. Division of Production, Wichita, Kans.

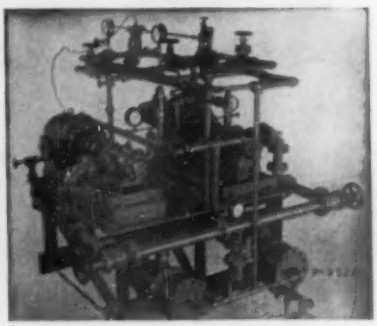
Price Hike Unavoidable

"An adjustment in crude oil prices is overdue and unavoidable. A general increase in crude oil prices has been made necessary and inevitable by higher costs of wages, steel and other materials.

"Despite rising costs, there has been no adjustment in over-all crude oil prices in almost 3 years and only one small increase in 8 years. All factors

COMPLETE RANGE OF SIZES AND MODELS IN BOTH MEDIUM AND HIGH PRESSURE TYPES

MORE COMPACT THAN EVER



P-952-A—Steam Turbine and Electric Motor drive gives flexibility in this compact Model P-ES2H size No. 25 unit.

NATIONAL AIROIL

FUEL OIL PUMPING AND HEATING UNITS

NATIONAL AIROIL Fuel Oil Pumping and Heating Units are specially designed to prepare, for combustion, all grades of fuel oil including No. 6 or Bunker "C" Oil and residuums. They will draw fuel oil from above ground or underground tanks, preheat it to proper constant temperature and deliver it to Oil Burners at an even pressure, best suited for the burners. Our Fuel Oil Pumping and Heating Units are the result of years of experience. They come completely equipped ready for steam, exhaust, condensate, oil suction, oil return and electrical connections. All valves, regulators, etc., are readily accessible. The piping arrangement is easily understood. These compact, space-saving units are available in a range of sizes and models in both Medium and High Pressure types. For complete details, write for our Bulletin 40 — very interesting and informative.

OIL BURNER and GAS BURNERS for industrial power, process and heating purposes.
STEAM ATOMIZING OIL BURNERS
SLUDGE BURNERS, Steam Atomizing
MOTOR-DRIVEN ROTARY OIL BURNERS
MECHANICAL PRESSURE ATOMIZING OIL BURNERS
DUAL STAGE. Combining Steam and Mechanical Atomization
LOW PRESSURE OIL BURNERS
AUTOMATIC OIL BURNERS, for small process furnaces and heating plants
GAS BURNERS
COMBINATION GAS & OIL BURNERS
FUEL OIL PUMPING and HEATING UNITS
FURNACE RELIEF DOORS
OBSERVATION PORTS
SPECIAL REFRACTORY SHAPES

NATIONAL AIROIL BURNER CO., INC.

1236 E. Sedgley Avenue, Philadelphia 34, Pa.
Southwestern Division:
2512 South Boulevard, Houston 6, Texas

Save up to $219 per mile

with new Kaiser Aluminum pipe and couplers!

As you can see in the chart below, *big* savings are possible when you use lightweight Kaiser Aluminum pipe and couplers instead of heavy steel pipe for your drill rig supply lines.

Laying one mile of 4-inch oil rig supply pipe*

Aluminum vs. Steel

	STEEL		ALUMINUM	
OPERATION	MAN HOURS	COST	MAN HOURS	COST
Loading	10.66 @ $2.20	$ 23.46	3.25 @ $2.20	$ 7.15
Stringing (Trucker)	1.66 @ $1.82	3.03	.83 @ $1.82	1.52
(Crew)	3.33 @ $2.20	7.33	1.66 @ $2.20	3.65
Connecting	43.33 @ $2.20	$ 95.33	3.00 @ $2.20	$ 6.60
Disconnecting	26.25 @ $2.20	$ 57.75	5.00 @ $2.20	$11.00
Pick-up and reloading				
(Trucker)	7.25 @ $1.82	13.20	1.33 @ $1.82	2.42
(Crew)	29.00 @ $2.20	63.80	5.33 @ $2.20	11.73
Total	121.48	$263.90	20.40	$44.07

Total savings with Kaiser Aluminum pipe—$219.83!

*Figures compiled from extensive installations by Kaiser Aluminum in Texas. Total savings could be more or slightly less, according to local conditions.

The main reasons for these huge savings are extremely light weight and easy coupling. A 30-foot length of 4-inch Kaiser Aluminum pipe weighs only 31 pounds, while an equivalent length of steel pipe weighs 323 pounds—293 pounds more!

The new quick-connecting aluminum couplers require no welding. One man easily joins pipe sections right in the field with no special equipment. Result: 61½ man-hours saved in disconnecting and connecting time!

Your nearby supplier stocks Kaiser Aluminum petroleum pipe in 30-foot lengths of 2, 3 and 4 inch diameters.

Skidding time reduced from 52 man-hours to only 12½ man-hours by using aluminum pipe instead of heavy steel pipe. One and a half miles of 4" aluminum pipe is an easy load in a truck built to carry steel pipe.

He also has the necessary couplers and fittings to complete your system.

Kaiser Aluminum petroleum pipe is roll-formed and induction welded from high-strength aluminum alloy sheet. Each length is hydrostatically tested at a pressure of 1000 psi. Inside surface is clad with high-purity aluminum to increase resistance to corrosion.

For further information on the pipe and couplers, contact the Kaiser Aluminum sales office listed in your telephone directory.* Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois; *Executive Office*, Kaiser Bldg., Oakland 12, California.

Kaiser Aluminum

setting the pace—in growth, quality and service

Information may also be obtained from the following suppliers:

REPUBLIC SUPPLY COMPANY
Republic Building (Home Office)
Oklahoma City, Oklahoma

DUNIGAN TOOL & SUPPLY COMPANY
1534 South Treadaway (Home Office)
Abilene, Texas

HENRY H. PARIS DISTRIBUTOR, Inc.

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Agent and Distributor for the Following Nationally Known Manufacturers:

ALTEN FOUNDRY & MACHINE WORKS
Lancaster, Ohio
Surface Equipment.

THE OHIO INJECTOR COMPANY
Wadsworth, Ohio
OIC Valves, Bronze, Iron, Cast, and Forged Steel for all purposes.

DRESSER MANUFACTURING DIV.
Bradford, Pa.
Seamless Welding Fittings.

OIL STATES EQUIPMENT COMPANY
Houston, Texas
OSECO Silvertop Fusible Plugs with renewable inserts for all types OIL COUNTRY BOILERS.

THE GORMAN-RUPP COMPANY
Mansfield, Ohio
Centrifugal Pumps.

STEEL FORGINGS, INC.
Shreveport, La.
Weld Saddles.

HARRISBURG STEEL CORPORATION.
Harrisburg, Pennsylvania
Forged Steel Flanges and Seamless Welding Couplings.

VOLCANO BURNER COMPANY
Houston, Texas
Volcano Superior and Gulf States All Steel Gas Burners for OIL COUNTRY BOILERS.

LOS ANGELES BOILER WORKS
Los Angeles, California.
Welding Caps—Dished & Flanged Heads.

WESTERN SAFETY BARREL STAND
Houston, Texas
Stand lifts, holds, tilts 55 gal. barrels Prevents spillage—easily loaded.

MILLS IRON WORKS, INC.
Los Angeles, Calif.
Seamless Swage Nipples, Bull Plugs & Welding Reducers.

WHEELING MACHINE PRODUCTS CO.
Wheeling, West Virginia
XL Steel Pipe Couplings for OIL COUNTRY TUBULAR PRODUCTS.

leave no alternative to an early correction in crude oil prices.

"Oil and gas have consistently been among the lowest items in the consumers' cost of living and will continue to be after the price is adjusted."

Russell B. Brown, general counsel for I.P.A.A., in report to membership.

Converted Conversion

Dear Sir:

Looking through your April 2 issue, I was pleased to find a set of conversion factors on page 137. At first glance, this seemed to be useful reference material. However, at second glance, I notice that the factor for converting barrels per day to gallons per hour is stated 1.7298. The correct factor is 1.75, as follows:

$$\frac{1 \times 42}{24} = 1.75$$

I have checked none of the other factors and it may be that they are all correct. However, it is likely that you will wish to have the entire table thoroughly reviewed since it is a type of material that will find wide use and should be published without any mistakes.

The Journal does look good these days. It is more useful than ever and you and your staff are very clearly doing excellent work.

L. S. Daniels
Hydrocarbon Research, Inc.
New York.

Editor's note: Reader Daniels is correct. The factor is 1.75.

Navy Move Assailed

"The Navy's proposal to drill for oil on San Nicolas Island is an unwarranted invasion of the private rights of citizens, an unjustifiable expenditure of the taxpayers' money, contrary to sound economics and sound public policy."

The Oil Producers Agency of California in public statement.

Warren Didn't Object

Dear Sir:

Your issue of February 27th on page 80 carried a write-up of the SACROC hearing before the Railroad Commission for an increased allowable. The statement was made that "The only objection came from Warren Petroleum Corp." This statement is untrue, and it has proven to be undesirable publicity.

We would like to make the record clear that we did not object to the increased allowable requested by SACROC. An examination of the transcript of the hearing will show we

watch lift COSTS GO DOWN

with GUIBERSON GAS LIFT EQUIPMENT

Guiberson's Complete Line of Gas Lift Equipment includes
Three types of Pressure Controlled Flow Valves
Type A
Check Valves—two types, spring loaded or velocity
Many types of mandrels, including Wrap-Around —Mashed In—Fluid Control
A full line of Controllers
Standard A
Type A Controller
Type C—Differential Pressure Flow Valves
. . . and a complete line of casing packers.

When wells won't flow, operators in many fields are meeting rising oil production costs with gas lift. And more and more engineers and field men are finding that Guiberson equipment plus Guiberson experience is the way to the lowest gas lift cost with the greatest economy in initial installation.

Guiberson's line of equipment is complete, designed to solve almost every type of gas lift problem. Guiberson experience, derived from thousands of satisfactory installations, is your assurance that your well will give maximum production for a maximum length of time. No matter what your gas lift problem—intermitting or continuous flow; using lease gas or recycled gas, from single or dual producing zones—look to Guiberson for the equipment and experience that will cut your gas lift costs.

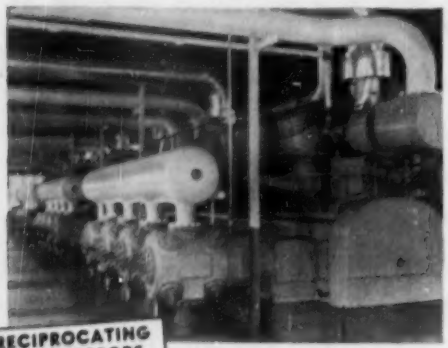
Write us for a recommended gas lift installation for your well.

Guiberson Gas Lift Equipment is protected by the following patents:
2,136,429 2,227,132 2,292,764 2,347,620 2,577,981
2,140,656 2,236,107 2,305,256 2,358,944 2,611,315
2,160,668 2,271,859 2,340,828 2,361,710 2,619,342
Other patents pending.

THE
GUIBERSON
CORPORATION
ESTABLISHED 1919 • DALLAS, TEXAS, U. S. A.
Sold By Leading Oil Field Supply Stores Everywhere

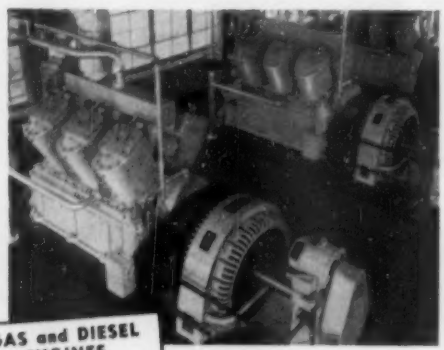
You can depend on I-R equipment

. . . because it's "job-engineered" with design, construction and materials to meet each application



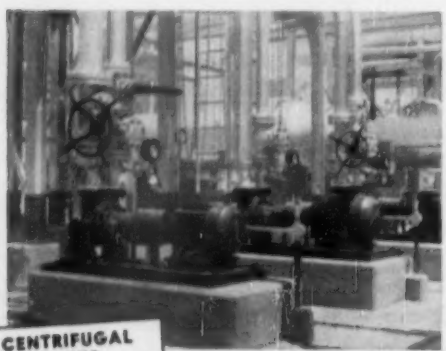
RECIPROCATING COMPRESSORS

Thousands of successful installations have established the dependability of I-R compressors. A complete line is available for handling air and other gases . . . for all types of drive including integral 4-cycle engine-driven units. Sizes range from ½ to 6000 hp; pressures to 35,000 psi.



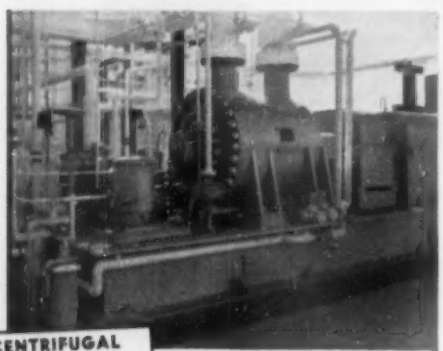
GAS and DIESEL ENGINES

For generating power and for driving pumps, blowers and other types of rotative equipment, Ingersoll-Rand builds a complete line of 4-cycle, V-angle gas engines and 4-cycle, cylinders-in-line diesels. Turbo-charged and naturally aspirated models available in sizes up to 2000 hp.



CENTRIFUGAL PUMPS

For moving liquids in refineries and through pipe lines, Ingersoll-Rand offers a complete line of centrifugal pumps. Single and multi-stage, horizontal and vertical units are available . . . many with built-in mechanical seals. Sizes for all pressures and capacities; for hot and cold liquid service; for all types of drive.



CENTRIFUGAL COMPRESSORS

A complete line of single and multi-stage centrifugal compressors and Turbo-Blowers is made by I-R for catalytic cracking, reforming processes, pipe-line service and for other air and gas applications. Capacities to 160,000 cfm; pressures to 2200 psi. Horizontally split and barrel types are available.

Ingersoll-Rand

11 BROADWAY, NEW YORK 4, N. Y. 14-311

Here's a suggestion: Ask your nearest Ingersoll-Rand engineer to tell you more about I-R equipment and how it can best meet your requirements. There are very few phases of petroleum production, refining and transmission that can't benefit in some way from the proved economy and dependability of I-R equipment.

COMPRESSORS . CONDENSERS . PUMPS . DIESEL ENGINES . AIR AND ELECTRIC TOOLS . VACUUM EQUIPMENT

proposed that an allowable limit of 400 bbl./day as requested by SACROC in its Rule 9 also be placed as a limit in SACROC's requested Rule 6.

We believe that this was a reasonable request, and in no way can be construed as an objection to the SACROC proposal for an increased allowable. No comments were made on other phases of the proposal.

H. F. Beardmore
Production Manager
Warren Petroleum Corp.
Houston, Tex.

Editor's note: Reader Beardmore is correct. The Journal error was due to a report of the hearing in which Warren's 400-bbl. (producing day) figure was converted to a 200-bbl. (calendar day) figure without identifying it as such. This figure appeared to be in opposition to the SACROC plan.

Tidelands Miracle

"It is almost a miracle that the Long Beach tidelands bill, adequately wrapping up solutions to many problems involved in the tidelands controversy, is now safely through the legislature and signed by Governor Knight.

"When the legislature convened a few short weeks ago, it appeared that the complex Long Beach issues would get scant attention at that session and would be put over at least until the 1957 regular session for possible action. And if there had been a continuance of the litigation—which this bill settles—the matter could have lingered on for years to the public detriment.

"The legislators and the city and state officials whose joint effort brought about a quick conclusion, and avoided years of uncertainty, have provided a notable demonstration that the democratic processes can work with speed and effectiveness."

Editorial in the Long Beach Press-Telegram.

CALENDAR OF EVENTS

APRIL

30-May 5 International Course on Atomic Energy, sponsored by National Industrial Conference Board, Westchester Country Club, New York.

MAY

1-3 Petroleum Industry Electrical Association, annual meeting, Statler-Hilton Hotel, Dallas.

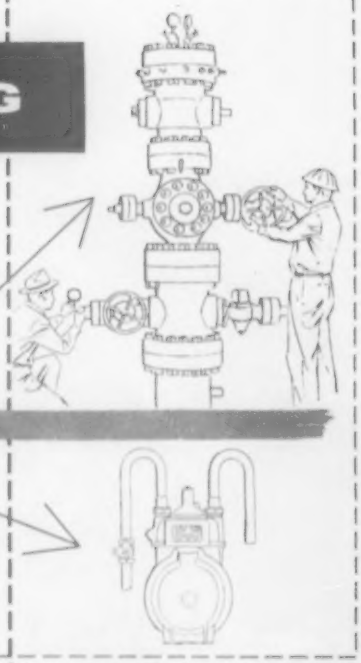
6-9 American Institute of Chemical Engineers, Roosevelt Hotel, New Orleans.

7-8 Gas Compressors Institute session, sponsored by University of Kansas and Southwest Kansas petroleum industry, Liberal, Kans.

TITRILOG

. . . to control sulfur compounds and odorants all the way from here

. . . to here



Sulfur compounds at the wellhead . . . *bad*. Sulfur compounds (such as mercaptans) at the consumer's end of the line . . . *a must*. Consolidated's TITRILOG helps control them at every step of the way . . . from purchase and sale of raw gas clear through to monitoring the odorants metered into consumer distribution systems for safety purposes.

An automatic, around-the-clock instrument, the TITRILOG provides an accurate, *continuous* record of oxidizable sulfur concentrations. It is an invaluable help in controlling corrosion by monitoring treated gas before it enters transmission lines. As a double check, it is also widely used to monitor gas in transit and to ensure that H_2S concentrations are within contract limits.

Both the stationary Model 26-102 (left) and the portable Model 26-103 (below) TITRILOGS are continuous, and highly sensitive, offer a wide range and instantaneous response. Both models report sulfur-compound concentrations as low as 0.1 ppm or 0.005 grains per 100 cubic feet. Compounds of specific interest may be separately determined.

For the complete story of CEC's TITRILOG, send today for Bulletin CEC 1810C-X7.

Consolidated Electrodynamics
CORPORATION
formerly Consolidated Engineering Corporation
300 North Sierra Madre Villa, Pasadena, California
ELECTRONIC INSTRUMENTS FOR MEASUREMENT AND CONTROL
Sales and Service Offices in: Albuquerque, Atlanta, Boston, Buffalo, Chicago, Dallas, Detroit, New York, Pasadena, Philadelphia, San Francisco, Seattle, Washington, D. C.

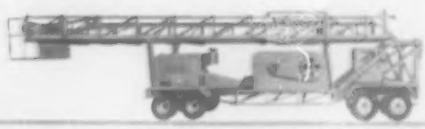
Cardwell's

There's a world of information in Cardwell's book, *"Slim Hole Facts with Data on Air Drilling."* 225 pages, covering Economic Considerations, Representative Drilling Programs, Drilling Techniques, Completion Techniques, Equipment Considerations including rigs, pumps, drill pipe, drill bits, and transportation charges, and an entire section on Air Drilling. This book is free to contractors and oil company executives. Write Philip L. McLaughlin, Director of Drilling Research, Cardwell Manufacturing Co., Inc., on your company letterhead.

WORLD-WIDE EXPERIENCE

LEADS THE WAY TO

REDUCED DRILLING COSTS



30 years' experience . . . just the starting point for Cardwell's development of higher quality, more efficient rigs for Slim Hole drilling, "Big Hole" drilling, servicing, and workover operations.

Today . . . Cardwell's improved organization with wider resources and broader experience is directing its advanced planning toward your drilling and servicing problems in a determined effort to bring you new and improved rigs that will reduce your costs.

There's no limit to the advantages you can obtain with Cardwell equipment and world-wide service. Whatever your requirements, we invite you to "Call on Cardwell."

CARDWELL MANUFACTURING COMPANY • Box 2001—Wichita, Kansas, U. S. A.

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ACCO's Great New Chain...

ACCOLOY X-WELD 125

• At last—a chain with welds as strong or stronger than the material . . . welds made with two projecting lugs that absolutely prevent kinking.

Accoloy X-Weld 125 Chains hang straight as a die. Every link is perfectly formed!

Accoloy X-Weld 125 Chain has almost countless uses: Slings, bundling, towing, boomer, general utility chains . . . It can be furnished in special analyses and heat treatments. Available in ¼", ⅜", ½", ⅝" and ¾" sizes.

Write the American Chain Division, York, Pa., for descriptive bulletin

The Secret is in the Weld!

This Accoloy X-Weld 125 link was ground and etched to show its big welded area—2½ times the size of welded area possible with other welding processes. This means more than double the security at the weld—and only X-Weld has it!

PATENT APPLIED FOR

ACCO

American Chain Division

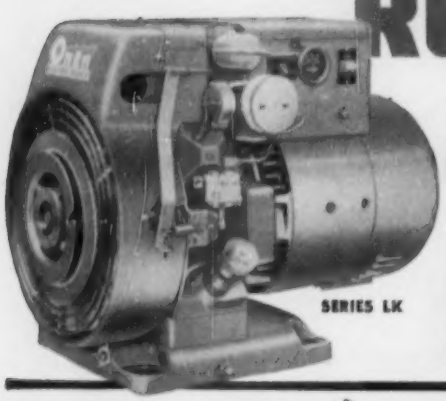
AMERICAN CHAIN & CABLE

York, Pa., Atlanta, Boston, Chicago, Denver, Detroit, Houston, Los Angeles, New York, Philadelphia, Pittsburgh, Portland, Ore., San Francisco, Bridgeport, Conn.

for Better Value

RUGGED

is the word for this



New ONAN 2,000-WATT ELECTRIC PLANT

SERIES LK

Put it to work on your toughest jobs!

PORTABLE POWER

Stands up under rough handling. Carry it, wheel it, or truck it.

PRIMARY POWER

Runs longer in continuous service. Dependable, economical.

Built to stand up where others can't! Powered by Onan 4-cycle, one-cylinder gasoline engine with Stellite-faced exhaust valve, longer-wearing bearings, efficient air-cooling. Onan all-climate generator is direct-connected. Compact, lightweight. Conservatively rated; economical operation. 115 or 230 volts, A.C. Recoil starter, electric starting, or automatic start and stop. Wide range of accessories. Other Onan models: 500 to 50,000 watts.

Write today for Special "LK" folder!

Onan ELECTRIC PLANTS

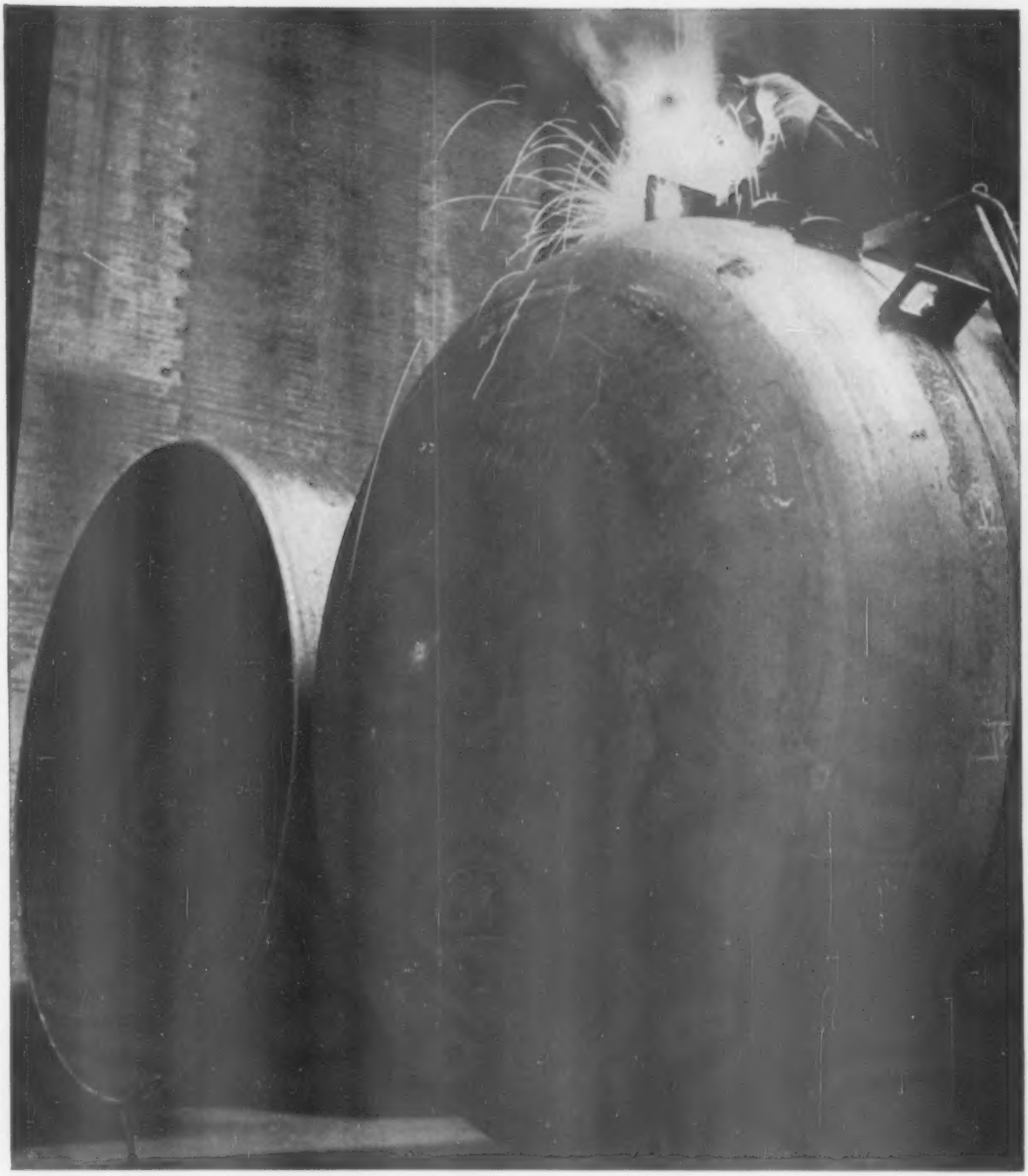
D. W. ONAN & SONS INC.

3568 UNIVERSITY AVE. S.E. • MINNEAPOLIS 14, MINNESOTA

7-11	American Welding Society, annual spring meeting, Hotel Statler, Buffalo.
9-10	Symposium on control of corrosion in the chemical industry, University of Buffalo.
9-10	National Association of Corrosion Engineers, Niagara frontier section, symposium on control of corrosion in the chemical industry, University of Buffalo.
9-11	Canadian Institute of Mining & Metallurgy, Petroleum and Natural Gas division, seventh annual technical meeting, Palliser Hotel, Calgary.
10-11	American Petroleum Institute, Division of Production, Pacific Coast district meeting, Statler Hotel, Los Angeles.
10-11	American Gas Association, Gas Supply, Transmission, and Storage Conference, Conrad Hilton Hotel, Chicago.
13-15	Empire State Petroleum Association, Statler Hotel, Buffalo.
13-16	American Petroleum Institute, annual pipeline conference, Shamrock Hilton Hotel, Houston.
14-15	American Institute of Mining, Metallurgical & Petroleum Engineers, Kansas regional meeting, Broadview Hotel, Wichita.
14-16	American Petroleum Institute, annual pipeline conference, Shamrock Hotel, Houston.
14-16	Petroleum Electric Power Association, eighth annual convention, Robert Driscoll Hotel, Corpus Christi.
14-17	American Petroleum Institute, Division of Refining, midyear meeting, Montreal.
16-18	American Gas Association, Chemical, Engineering, and Manufactured Gas Production Conference, Benjamin Franklin Hotel, Philadelphia.
17-18	Rocky Mountain Petroleum Sections, American Institute of Mining, Metallurgical & Petroleum Engineers, Gladstone Hotel, Casper, Wyo.
22-24	Pennsylvania Gas Association, Pocono Manor Inn, Pocono Manor, Pa.
24-25	Natural Gas and Petroleum Association of Canada, Sheraton Brock Hotel, Niagara Falls, Ont.
24-25	Western Petroleum Refiners Association, Michigan Regional Meeting, (location to be announced).
24-25	Kentucky Oil and Gas Association, annual meeting, Lafayette Hotel, Lexington, Ky.
28-30	Chemical Institute of Canada, 39th annual conference and exhibition, Sheraton-Mount Royal Hotel, Montreal.
30-June 1	Texas College of Arts & Industries, eleventh annual short course in Gas Technology, Kingsville, Tex.
30-June 2	Interstate Oil Compact Commission, Dallas.

JUNE

3-8	Society of Automotive Engineers, summer meeting, Chalfonte Haddon Hotel, Altantic City, N. J.
6-8	American Society for Quality Control, tenth annual convention, Palais du Commerce, Montreal.
10-15	American Petroleum Institute, Production Division midyear standardization conference, Brown Palace and Cosmopolitan Hotels, Denver.
11-15	American Institute for the Advancement of Science, Gordon Research on Conference on Catalysis and Petroleum, Colby Junior College, New London, N. H.
13	Pennsylvania Grade Crude Associa-



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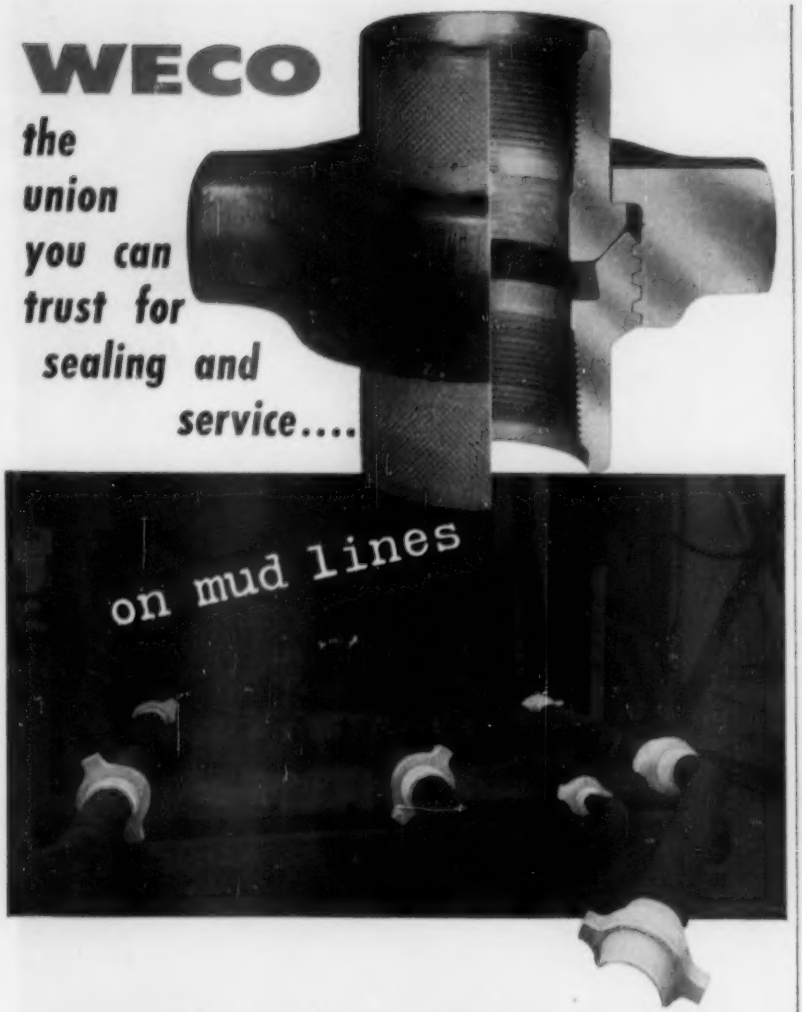

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tion, thirty-third annual meeting, Bradford, Pa.

17-22 American Society for Testing Materials, annual meeting, Chalfonte-Haddon Atlantic City, N. J.

17-23 World Power Conference, Vienna.

21-22 Western Petroleum Refiners Association, regional technical—industrial relations meeting, Broadview Hotel, Wichita.

21-23 American Association of Petroleum Landmen, annual convention, Denver.

26-29 Canadian Gas Association, Manoir Richelieu, Murray Bay, Que.

28-30 Rocky Mountain Oil and Gas Association, board of directors, Hotel Utah, Salt Lake City.

AUGUST

2-4 Rocky Mountain Mineral Law Foundation, Second Annual Institute, University of Colorado, Boulder.

SEPTEMBER

11-13 Pacific Coast Gas Association, annual meeting, Coronado, Calif.

13-15 Chemical Institute of Canada, third Western Regional Conference, Edmonton, Alta.

17-21 Instrument Society of America, eleventh annual international instrument-automation conference and exhibit, New Coliseum, New York City.

20-21 Western Petroleum Refiners Association, regional technical-industrial relations meeting, Hotel Henning, Casper, Wyo.

20-21 Mid-Continent Oil and Gas Association, Louisiana-Arkansas division, annual membership meeting, Roosevelt Hotel, New Orleans.

24-26 American Society of Mechanical Engineers, petroleum mechanical engineering conference, annual meeting, Statler-Hilton Hotel, Dallas.

26-28 Rocky Mountain Mineral conference, American Institute of Mining, Metallurgical & Petroleum Engineers, Newhouse Hotel, Salt Lake City.

OCTOBER

2-3 Texas Mid-Continent Oil and Gas Association, thirty-seventh annual meeting, Rice Hotel, Houston.

7-9 American Association of Oil Well Drilling Contractors, annual meeting, Texas Hotel, Fort Worth.

14-17 American Institute of Mining, Metallurgical & Petroleum Engineers, Petroleum Branch, fall meeting, Biltmore Hotel, Los Angeles.

15-17 American Gas Association, annual meeting, Atlantic City, N. J.

18-19 Western Petroleum Refiners Association, regional technical-industrial relations meeting, Rufus Garrett Hotel, El Dorado, Ark.

22-24 Rocky Mountain Oil and Gas Association, annual convention, Cosmopolitan Hotel, Denver.

29-Nov. 1 Society of Exploration Geophysicists, national convention, New Orleans.

NOVEMBER

7-8 Philadelphia section, Instrument Society of America, Symposium on Process Data Logging, Stratford Hotel, Philadelphia.

12-15 American Petroleum Institute, annual convention, Conrad Hilton Hotel, Chicago.

19-20 American Institute of Mining, Metallurgical & Petroleum Engineers, North Texas Secondary Recovery Symposium, Municipal Auditorium, Wichita Falls.

25-30 American Society of Mechanical Engineers, Statler Hotel, New York.

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JOURNALLY SPEAKING . . .

Helps for Geologists

AFTER scanning the advance proofs of the special articles in this exploration issue we concluded that while there probably is some pretty good stuff for geologists in this material it still doesn't answer all the questions of the oil-hunting fraternity.

So, following our policy of always trying to be helpful, we dug through our bottom drawer of clippings for unclassified nuggets of knowledge on the subject of oil, finding same.

•

First thing we came up with was the answer to the riddle of the age of the earth. We know that geologists are always puzzling over the ages of rocks, so they ought to be much interested in learning how old the earth is. The answer comes from a professor in Pennsylvania. He has worked out an equation for measuring the age of the earth by computing the speed with which uranium decomposes into thorium, then into protactinium, and so on until it becomes lead.

He says this is just as easy as telling time by counting the sand grains falling through an hourglass and when half of them are through it would be 30 minutes except that you have to allow for the fact that pressure makes them fall faster when the top half is full. (That's a scientific nicety we'll bet most egg-timers overlook.)

Well, the professor checked his theory against other cosmic calendars such as sedimentation, saltiness of the oceans, carbon 14, rotation of spiral nebulae, and the brightness of binary stars, and was so satisfied with the results that he didn't hesitate to announce his conclusion: The earth is somewhere between 2 and 6 billion years old. That ought to be close enough for geologists.

•

Having solved that problem, we now turn to another matter that gives geologists some concern—dry holes, how to avoid same. We have here an excerpt from the report of a foreign oil company that has done very well on that score.

"Of 507 wells drilled," it says, "337 have been producers, 101 test holes, and 69 geological exploration holes." There you have it. Not a dry hole in the lot. If you geologists would take a tip from this outfit and drill more test holes and geological exploration holes you wouldn't have to report any dry holes and your success ratio would look a lot better.

•

That company wasn't operating in Russia, but we deduce that the Russians have a similar way of avoiding dry holes. Another clipping quotes an escaped Soviet geologist as saying that behind the Iron Curtain it's a criminal offense to drill a dry hole, and the geologist who drills one is apt to wind up in Siberia. Be glad you live in the Land of the Free. Here a geologist who locates too many dry holes winds up as a consultant.

•

Here's a letter to Dr. Frank J. Gardner, the Journal's exploration editor, from a preacher in Virginia. He said that in excavating for a new church he noticed that the soil looked so much like the soil of Louisiana that he figured there must be oil under it. So he put a compass on a lump of the dirt and the needle spun 'round and 'round. He asked Frank's advice on development work and offered to split the profits between him and the church.

But Frank, the coward, refused to assist or even to advise. He referred the preacher to a consulting geologist. And this is the same Frank Gardner who has been going around to geological meetings making speeches urging geologists to be more imaginative, adopt new thinking, discard hidebound prejudices, embrace novel ideas, take more risks, explore new provinces. Yet when an opportunity to do just that is handed to him on a silver platter, Frank refuses to practice what he preaches.

•

If, in spite of that, you still want to read Frank's philosophy, there's a summary of his speech in the news section of this issue. And if, after reading that and after digesting all the tips in this column, you want more dope, study the batch of special articles Frank's assistants assembled while he was out speechifying. They contain some of the new ideas Frank says geologists ought to have.

—*Henry D. Ralph.*

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How to find more oil in the United States

THERE'S a growing feeling that the United States will not be able to find enough new oil reserves to meet the skyrocketing demands of the oncoming generation.

Various long-range forecasts indicate that the domestic industry will have to find something like 100 billion barrels of new crude in the next couple of decades in order to hold its relative position. This calls for a higher discovery rate than the postwar average.

Admittedly oil is getting harder and more expensive to find. Geologists and geophysicists are a bit gloomy about the future of their occupations. Predictions that U. S. output will reach a peak and turn downward in 15 or 20 years are common. More and more American companies are turning abroad in the hope that foreign countries will yield bigger discoveries at lower costs.

ARE WE SELLING America short with this attitude? Is the decline of the domestic industry inevitable? Is this nation ready to surrender its petroleum position without a struggle?

There is much undiscovered oil beneath our land; of that there can be no doubt. Nor is there doubt that techniques for finding it will improve unless a defeatist attitude overwhelms our scientists and our investors.

Much of the gloom stems from failure to distinguish between proved reserves and natural resources. Our resources for finding oil include undrilled land, progressive technology, imaginative thinking, willingness to take risks, expanding markets, and incentive of profits.

If we run out of these historic resources, this nation will run out of oil. Are we running out of them—or running out on them? Several of these factors are within the control of national policies—such as taxes and imports—at which our legislators should take an objective, long-range look.

The fact that oil imports have increased faster than domestic production is interpreted by some as proof that the U. S. industry is physically incapable of much expansion. But isn't this mixing cause and effect? There is just as much evidence that high imports have created the poor domestic showing by cutting into the incentives of markets and profits.

OIL WILL COST MORE to find in the future, but it can be found if there are incentives. And the cost to the American public, in terms of slightly higher oil prices, will not be burdensome if we have sound taxation and foreign-trade policies. The price will be cheap in terms of national defense alone.

Don't sell the U. S. oil industry short yet. A little more incentive in the form of a profitable market will result in vast new reserves of petroleum. It always has in the past.

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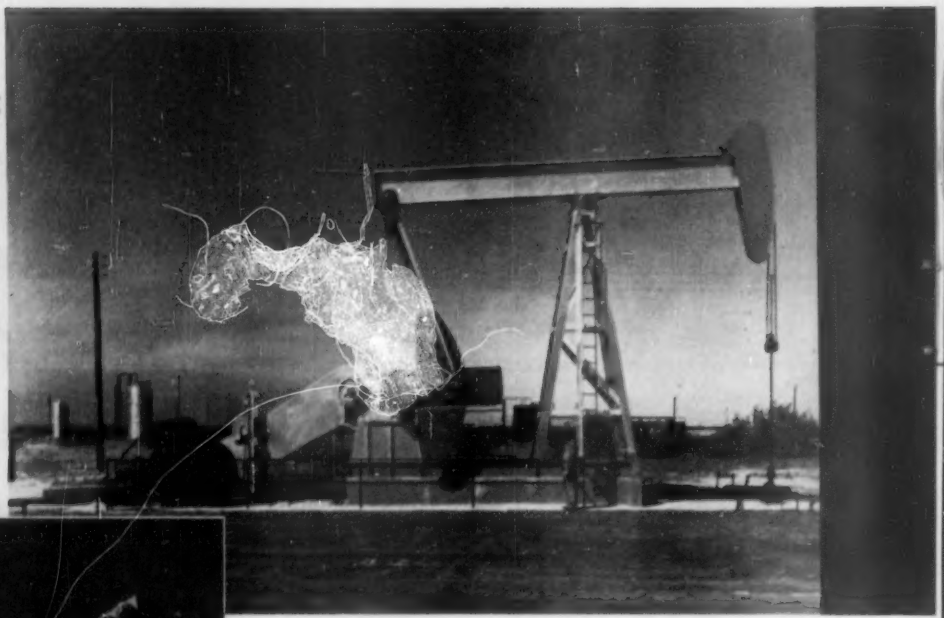

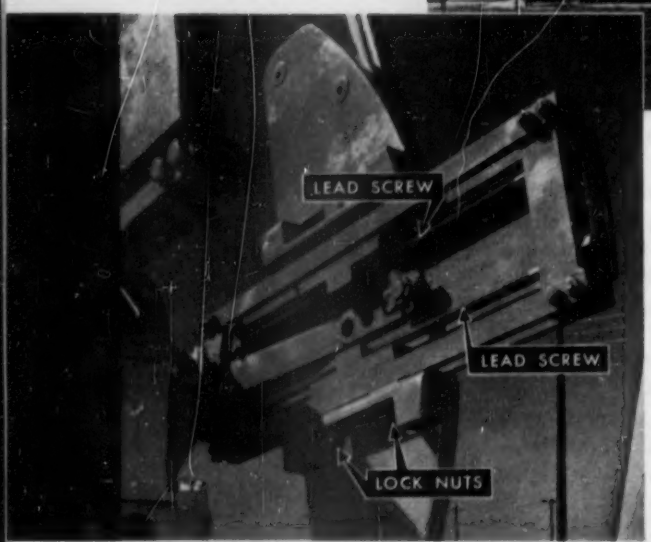

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Current and significant in . . .

The Industry This Week

Industry

• **Deals were cooking fast** between companies in the industry last week. These are the developments:

British American acquired the assets of Canadian Gulf in a complicated deal which eventually means Gulf Oil will control the Canadian firm. P. 82.

W. R. Grace & Co. entered the oil business by taking over Cosden Petroleum Corp. of Big Spring, Tex., in a $55 million stock transaction. P. 83.

American Petrofina, Inc., was organized as the American arm of the Belgian oil group. It's purpose: To become a major integrated U. S. oil company. First move will be to purchase stock control of Panhandle Oil Corp. P. 92.

Shorter work week for drilling crews is talked by contractors. But they report footage and day rates must rise if the change comes this year. Switch from 7-day week would be expensive and complicate a labor shortage. P. 88.

Production

• **The world's deepest hole** is now the world's deepest producer. The Louisiana wildcat came in initially for 500 bbl. daily from sands at 21,443 ft. It has dropped to 250 bbl. daily which prompted owners to plan further testing. P. 84.

A big discovery allowance for 1-mile stepouts has been discontinued by Texas Railroad Commission. In future the bonus allowance will go only to bona fide new-pool openers. P. 98.

Exploration

• **Finding an East Texas field every 15 months** is the challenge facing exploration men. Drilling in new areas and a change in exploration thinking may turn the trick. P. 80.

Stepped up geological research and systematic cataloguing of all known oil data are advanced also as possible aids in the oil search. P. 92.

French firm has walked off with a prize concession in Libya along the Algerian border. A successful wildcat in Algeria recently made the acreage most attractive. P. 102.

Processing

• **Isomerate process developed** by Pure Oil may offer the refiner a new tool for upgrading less desirable feed stocks into high-octane gasoline components. P. 86.

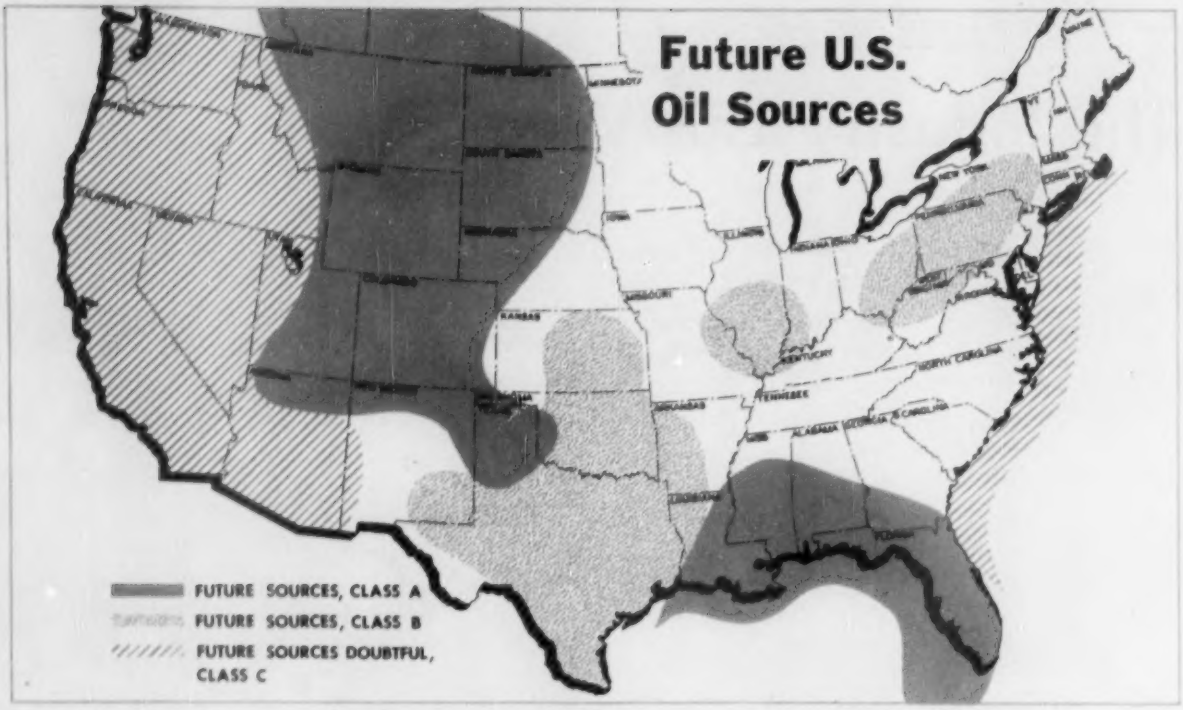
British Columbia's first gas-processing plant will be built by Pacific Petroleums to handle Peace River area gas. It will extract sulfur and remove natural-gas liquids. Residue gas will go to Westcoast Transmission. P. 91.

Petrobras has let contracts for expanding the Mataripe refinery to 37,000 bbl. daily. It is the first step in a move to increase Brazil's refining capacity to 200,000 bbl. daily in 5 years. P. 103.

Pipelines

• **Death knell for a subsidized Gulf to East Coast crude line** may have been sounded last week. Defense Mobilizer Flemming says federal aid isn't justified. P. 87.

Conversion of the Little Big Inch to products has been set back at least a year. Texas Eastern says the delay has been forced by suits of competing barge operators. The new target date: July 1, 1957. P. 98.



An East Texas every 15 months?

Finding Enough Oil Is the Challenge

Dr. Frank J. Gardner

IF American oil finders discover enough new crude to supply the vastly increased demand between now and 1980, they're going to have to perform discovery miracles.

This is the consensus of exploration people today. They estimate they'll have to find 100 billion barrels of new reserves to meet the country's needs in the next 25 years. And that's equivalent to finding an East Texas field every 15 months.

Can they do it? Not with present methods and present thinking.

The disappointing rate of discovery in the past few years indicates that unless some new method of exploration appears, or some presently unknown new province is discovered, the amount of new oil found each year will decline.

There's a good chance, however, that even if the so-called "giant" fields are not found, the collective reserves of smaller discoveries, achieved through vastly increased drilling, may fill much of the need. This will turn the trick when combined with expected success in ballooning secondary recovery and commercializing the nation's enormous shale-oil and tar-sand resources.

The bright side . . . It has become quite fashionable in recent months to make alarming predictions of oil shortage, productive peaks, declining discovery, and a dearth of drillable prospects. But geologists disagree. They're optimistic.

There are many reasons for this. First and foremost, there are immense stretches of undrilled or barely drilled territory in this country today. Much of it, in the opinion of the oil finders, is prospective oil territory.

Take a look at the nearest map and you'll see what they mean. The entire states of Arizona, Nevada, Florida, Georgia, Washington, Oregon, and most of Alabama have barely been touched. The Rocky Mountain states, all six of them, can only be classed as "sparsely drilled." And the mounting discovery success in all parts of that region point to a future drilling program that will eclipse all that has gone before.

Another reason for optimism is based on history. None of the great producing provinces of the country has failed to come up, year after year, with important new discoveries. They may be deeper unsuspected pays, surprising extensions to productive boundaries, or commercial pools attributable only to improved techniques in drilling and completion practices.

With some chagrin, geologists point out that many of the greatest oil fields in the United States were discovered purely by accident. It's still happening today. They believe that when accidents cease to happen, then oil discoveries also will cease. Despite his expanded knowledge and the great array of new tools to work with, the oil finder still counts on an important discovery ingredient of "60 per cent luck."

The oil finders also cite a lethargy in thinking as an important cause for concern. And they're the first to admit it's a weakness of their own as well as of management.

Oil men are traditionally timid about plunging into unknown frontiers of exploration. All through history, it has been the job of one imaginative, aggressive, apparently stupid wildcatter to lead the parade of landmen, geologists, and drillers into a new land. And these leaders have become scarce. Patillo Higgins, Frank Pickrell, Dad Joiner—these are names to remember.

Today, companies have taken over the job of opening new provinces. Amerada Petroleum Corp. did it in Williston. Shell Oil Co. laid Nevada wide open.

This is the Journal's Annual Exploration Number . . .

. . . And this article is an analysis of the industry's oil-finding outlook by the Journal's exploration editor. It points up the tremendous task faced by exploration men if they are to find the crude which will be required in the years of mounting demand ahead. It suggests areas in which major future reserves may be found. It also suggests that new thinking—as well as new equipment and new techniques—will be essential if tomorrow's demands will be met by the oil industry as we now know it. In a sense it's an editorial. But more than that it's a concensus of the thinking of the nation's respected oil explorers.

And the major offshore operators started a whole new industry out in the Gulf of Mexico.

It could well be that the legendary tale of the independent who asked "How far must I be restrained by science?" is not without its element of truth. Many geologists admit they are prone to fall into thinking ruts, and that a new rash of oil discovery must be preceded by a break with routine thinking. Any survey of drilling activity will reveal that the great majority of effort is being concentrated in a very few areas of old, established production.

The future . . . What are some of the greatest hopes of the oil finders for future oil fields? Roughly, they can be classified three ways:

. . . Regions in a primitive stage of of exploration. These are the provinces in the "barely drilled" category, such as the Pacific Northwest, the Atlantic Coastal Plain, the Southeastern states, the Western Rockies, and most important of all, the offshore waters.

. . . Regions in a youthful stage of exploration. These areas are firmly established as oil productive. Most of the larger structural uplifts in them are known and drilled, but they harbor a multitude of elusive traps for oil. Examples of these are South Louisiana onshore, the Eastern Rocky Mountains, the Permian basin, and the Anadarko basin.

. . . Regions in a mature stage of exploration. These older oil provinces yield new pools and fields only after concentrated study and search for flank sands, small structures, and deeper zones in old fields. These are typified by the Texas Gulf Coast, the Mid-Continent area, North Central Texas, and coastal California.

What is needed to find the 100 billion barrels of new oil in 25 years?

The oil finders have their answers to that one, too. They feel that oil certainly is here to be discovered, and that these eight big assists will ease the task:

. . . Money. Bigger exploration budgets are a must, if the immensely increased amount of drilling to find new fields is to be accomplished. A timely increase in the price of crude, they feel, is a necessary prelude to these bigger budgets.

. . . Geophysical tools. Devices are needed that can detect a stratigraphic trap in the subsurface. Most of the largest fields in the world are in strat traps, and most of them were found by accident. Oil finders feel that many more must be awaiting discovery, and a geophysical method to detect them would be a godsend.

. . . Big thinking. The objective approach to oil finding must be reinstated in the minds of geologists who are prone to fall into a thinking rut. They must think big, study big, and sell big if they are to perform a proper job of salesmanship to management.

. . . Competition and competence. Geology and geophysics students must be well-schooled in the basic fundamentals of their science. Many exploration managers complain of poorly prepared graduates. At the same time, schools complain of short money, short equipment, and short supply of teachers. Sharp correction of these problems is essential to future crops of competent graduates. And when these graduates enter the business world, they must be free to operate in competitive enterprise.

. . . Better drilling. The goal is faster, cheaper and more diagnostic drilling. Careless drilling is blamed for more overlooked oil pools than any other cause by the oil finders.

A case in point—the discovery of the Clear Fork pool lying just above the Spraberry pool 4 years after the original boom that called for "full-speed-ahead" drilling to the lower objective. True, the Clear Fork may not have been an economic objective in itself, but early dual completions might have bailed out many a well from the red.

A way to reconcile "cheaper drilling" with "more diagnostic drilling" is a big problem. The only answer appears to be a new method of drilling, and oil finders do not discount the eventual appearance of atomic drilling, sonic drilling, and a myriad other possibilities.

. . . Geological - geophysical union. The two branches of exploration science must and will work together, and even more closely. This is here now, in many companies, and to quote one eminent authority, ". . . whoever practices the one must of necessity practice the other."

. . . Research. Geological and geophysical research, coupled with engineering research on secondary recovery and on oil extraction from shale and tar sand, can result in giant strides toward the goal of 100 billion barrels of new oil by 1980.

The oil finders are buckling down to the problem of sedimentation, reservoir rock vs. source rock, and oil migration, to mention a few studies. Essential to this research is yet another vital need—free exchange of information between companies.

Too, engineers are tackling the problem of secondary recovery with renewed vigor. They could conceivably release 180 billion barrels of so-called "unrecoverable" oil to the market. Oil shales and tar sands, and other types of semi-solid hydrocarbon sources, could yield over a trillion barrels of oil on the North American continent alone.

. . . "Crazy Stuff." Aggressive exploratory vision, spiced with imagination and leavened with geologic knowledge, must lead the oil finders away from routine thinking into new vistas of exploration in virgin areas.

One prominent oil finder describes it simply as "crazy stuff." Not in the terms of insanity, but in the sense of the unorthodox.

So the oil finders are confident—confident and optimistic. They believe they can do the job and that new oil provinces will come. Their faith belies the alarmists. They believe they will continue to perform new miracles in exploration.

B.A. Buys Canadian Gulf

• Gulf gets new markets, majority ownership of British American, which in turn improves its crude-oil position

PITTSBURGH.—British American Oil Co., Ltd., of Toronto is acquiring all the assets of Gulf Oil Corp.'s wholly owned Canadian subsidiary, Canadian Gulf Oil Co.

British American has offered Gulf more than 8,000,000 shares of restricted common stock for Canadian Gulf. Gulf's executive committee last week authorized acceptance of the offer. It will be presented to B.A. stockholders for approval at a special meeting May 18.

The deal will give Gulf 59 per cent ownership of British American, in which it already holds 22 per cent interest.

Neither company mentioned the other half of the long-rumored transaction, the expected cash sale to Gulf of British-American Oil Producing Co., Dallas, B.A.'s wholly owned producing subsidiary operating in the United States, for about $150,000,000.

The British American stock to be issued for Canadian Gulf's assets is worth $366,000,000 at current market prices, and makes this one of the biggest deals in the history of the oil industry.

It's the third major move by Gulf this year. The company earlier acquired 95 per cent of Warren Petroleum Corp., Tulsa, in an exchange of stock worth more than $125,000,000. The announced purchase of $120,000,000 in Union Oil Co. debentures could result in 25 per cent Gulf ownership of Union *(The Oil and Gas Journal, April 9, page 67)*.

What's involved . . . Gulf will gain majority ownership of British American through the addition of 8,335,648 restricted shares of B.A. common to the approximately 2,002,000 shares it already has.

The restricted shares rank equally with other outstanding common stock except for dividend purposes. Gulf will waive dividend payments until British American earnings rise to a suitable level.

Gulf will end up with about 10,337,648 of the 17,435,647 British American shares outstanding, provided stockholder approval is won.

W. K. Whiteford, president of Gulf, said Gulf saw a "good opportunity without expending any cash" to find facilities for marketing of crude oil in Western Canada and for expanded crude-oil markets.

The deal also will strengthen its U.S. crude position when the second phase is completed. Gulf has 14 billion of its more than 16 billion barrels of reserves concentrated in the tiny Middle East shaikdom of Kuwait. The Canadian Gulf production sharply improves B.A.'s ratio of production to refinery runs.

Whiteford formerly headed the company which Gulf will now control. He served as president of the U. S. subsidiary and of the parent company, and resigned as chairman of British American December 1, 1951, to join Gulf as a director and executive vice president.

W. K. WHITEFORD
... Engineer behind a big deal.

M. S. BERINGER
... A high degree of integration.

British American will rank second to Imperial Oil, Ltd. (Jersey Standard) in crude production in Western Canada and will increase its reserves fourfold. It will acquire Canadian Gulf's more than 9 million undeveloped acres in Western Canada and its major pipeline facilities.

For British American it means "the achievement of a high degree of integration of production with its refining, transportation, and marketing facilities in Canada," M. S. Beringer, company president, told stockholders.

Beringer said his offer to Gulf was prompted by the fact that British American production, both in Canada and the U. S., was only 32 per cent of refinery requirements last year. Canadian Gulf's properties will assure his company adequate reserves in relation to expanded refinery capacity and mounting Canadian demand.

British American operation . . . British American now has net daily crude production of 28,772 bbl. Only about 3,800 bbl. of this total comes from Western Canada. The rest is from leases in the United States, where the subsidiary's reserves exceed 87 million barrels of oil and 300 billion cubic feet of natural gas.

At the end of 1955, British American owned or had an interest in 167 oil wells and 21 gas wells in Western Canada with net crude reserves of 26 million barrels.

Refining capacity amounts to 95,700 bbl. daily in five refineries at Moose Jaw, Sask.; Calgary and Edmonton, Alta.; Clarkson, Ont.; and Montreal, Que. The Montreal refinery, with capacity of 45,000 bbl. daily, operates on Venezuelan crude.

B.A.'s pipeline ownership ranges from 15 per cent to 100 per cent in six crude lines and one products line. The company moved 98,800,000 bbl. of crude and products last year by pipeline, tank car, and truck. Another 9,700,000 bbl. was moved by Trans-Mountain and Interprovincial pipelines for the company's account.

Marketing outlets include more than 7,500 dealers and farm distributors across Canada.

Canadian Gulf holdings . . . Beringer, in addressing stockholders last week, outlined Canadian Gulf's "remarkable chain of successes" in western Canada.

He said developing the same reserves through British American's own efforts would take "many years of intensive exploration and heavy expenditures."

At the end of 1955 Canadian Gulf

had working interests in 542 oil and condensate wells with an average production for the year of more than 24,000 bbl. daily. This is expected to rise to 30,000 bbl. daily this year.

Net crude reserves are estimated at 300 million barrels, or about 9 per cent of the total for all of Canada.

Natural gas reserves are estimated at 3 trillion cubic feet, including 90 per cent of the reserves in Pincher Creek field, Alberta. This field is expected to be a major supplier for any transmission line to Eastern Canada.

A joint committee representing both companies, along with DeGolyer & McNaughton, Dallas consultants, evaluated all properties involved before British American made its offer.

Beringer said his company could become the largest natural-gas producer in Canada as well as the largest producer of sulfur and liquefied petroleum gases with Canadian Gulf properties added to its own.

He very pointedly said that the Canadian identity of British American will continue in all respects and that operations will remain in the hands of British American directors.

"As part of the future financing program for the combined enterprise," Beringer said, "a substantial offering of equity capital will be made to the Canadian public so as to permit greater Canadian participation in the ownership and development of the petroleum resources of Canada."

Gulf, B.A. earnings . . . Gulf, an international giant with assets of $2,160,821,020, ranks fourth in size among U. S. oil companies.

Net income last year amounted to $218,064,000 on revenues of $1,895,670,000.

British American had gross income of $271,066,000 and net profit of $20,613,000. Total assets were listed at $263,825,000.

Pipeline Moving to Salt Lake

SALT LAKE CITY.—Pacific Northwest Pipeline Corp. is establishing permanent operating headquarters here.

Offices are being set up here by Pacific Northwest president C. R. Williams and four vice presidents—R. C. Frederick, A. B. Allyne, Allen B. Hiatt and J. M. Clark. The vice presidents are moving to Salt Lake City from Houston, Tex., where the firm has maintained headquarters.

The company is building a natural-gas line from the San Juan basin to Washington. About 225 persons will be employed here before delivery of the pipeline's gas into Idaho, Oregon, and Washington begins in August. The staff will be expanded eventually to some 600 persons.

Cosden Petroleum Sold

W. R. Grace & Co. continues expansion into chemicals, enters oil business by merging with Big Spring company

NEW YORK.—W. R. Grace & Co., an international chemical, shipping, mercantile, and banking firm, is entering the oil business by merging with Cosden Petroleum Corp. of Big Spring, Tex.

The agreement, announced by Raymond L. Tollett, president of Cosden, and J. Peter Grace, president of Grace, is subject to approval of directors and stockholders of both companies.

Grace will pay the equivalent of $55,000,000 for the integrated oil and petrochemical company through issuance of 102½ shares for each 100 shares of Cosden common. Cosden has 1,088,138 shares outstanding.

Cosden will be operated as a wholly owned subsidiary, with Tollett remaining as president. He and Thomas Sheridan, senior director of Cosden, will become directors of Grace.

The deal is expected to result in accelerated expansion of Cosden, which has enjoyed extremely rapid growth since its founding in 1930 by the late J. S. Cosden.

Cosden operations . . . Cosden has a 28,500-bbl. ultramodern refinery at Big Spring, where it also is building a $3,000,000 styrene unit representing further expansion into petrochemicals.

Production of aromatic chemicals will be increased about 30 per cent on completion of a 3,000-bbl. daily Rexformer this summer. Fifteen to 20 per cent of its products sales comprise aviation gasoline and jet fuel to the federal Government.

Crude production is around 2,800 bbl. daily and reserves are estimated at 20,000,000 bbl.

Cosden Pipe Line Co., a wholly owned subsidiary, operates 119 miles of 2 to 8-in. pipelines. A 6-in. products line is being laid between Big Spring and Abilene.

Grace's expansion . . . The purchase of Cosden is the outgrowth of a study made after World War II aimed at diversifying operations.

Founded 102 years ago in Peru, Grace now owns 24 businesses in 22 countries. It was originally mainly a shipping, mercantile, and banking company. But under Peter Grace, 2½ years of research was conducted to determine the most promising areas of expansion.

The conclusion was that chemicals were the best bet. Oils also ranked high but Grace chose to move first into chemicals. In 1952 they represented only 2 per cent of the firm's total operating revenue. Now they account for about 50 per cent, coming from an investment of $153,000,000, the past 3 years.

Grace chemicals group . . . Its chemical operations comprise seven divisions.

Cryovac makes plastic bags. It operates one Canadian and three U. S. plants.

Dewey & Almy Chemical Co. makes organic chemicals, sealants, and specialties, operating five U. S. plants and one in Canada. Dewey & Almy Overseas division handles sales and manufacture of those chemicals with seven plants, four in Europe, two in South America, and one in Australia.

Davison Chemical Co. makes catalysts, silica gel, and fertilizers in 20 U. S. plants and one in Canada.

Grace Chemical Co. operates a $70,000,000 ammonia plant in Memphis. The Grace Chemical Co. research and development division has laboratories in New York City.

The newest division is Polymer Chemical, which is now building a polyolefin plant at Baton Rouge.

Other holdings, income . . . The company's best-known operation is the Grace Line, which runs freight and passenger service between the United States and South and Central America.

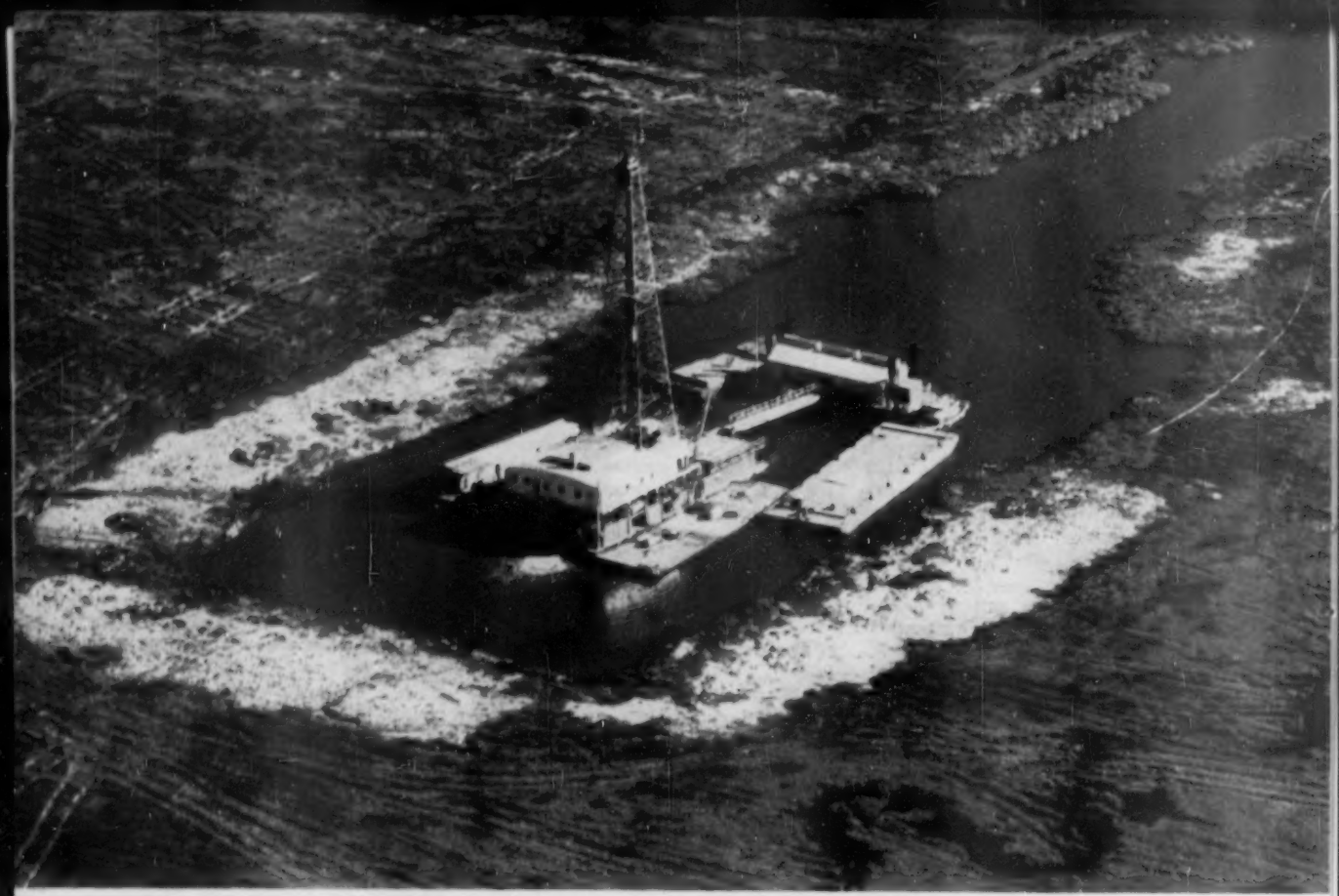
Grace also controls Grace National Bank, New York City, and has large insurance brokerage and outdoor advertising interests.

Earnings last year were $18,780,394 on operating revenues of $427,066,329. This compares with Cosden's earnings of $4,500,000 for the year ending May 1, 1956.

Sinclair Line Completed

INDEPENDENCE, Kan.—The northern section of Sinclair Pipe Line Co.'s Texas "big inch" crude-oil line has been completed by River Construction Co. of Fort Worth, Tex. The 152-mile line extends from Jacksboro to Teague, Tex.

The 18-in. facility, which replaces several old, small-diameter lines, is being tested and will go into service soon. It has a capacity of 105,000 bbl. daily. A second section from Teague to Houston will be built in the near future.



This Richardson & Bass wildcat has added 3,500 ft. to the old mark as . . .

New Producing-Depth Record Set

PORT SULPHUR, La.—The first barrel of oil has been brought to the surface from the record-breaking depth of 21,443 ft. To get that barrel of oil cost Richardson & Bass, John W. Mecom, Freeport Sulphur Co., and others $2½ million.

The well's owners still are far from certain they will get their investment back. Initial tests of a Miocene sand from 21,443-65 ft. were very encouraging. But there later was a drop in flow rate that will make more testing necessary.

Early last week, the 1-L Humble-L.L.&E. came in making more than 500 bbl. of 38°-gravity oil per day through a 8/64-in. choke. Gas-oil ratio was 1,200 cu. ft. per barrel, and tubing-head pressure was 7,000 psi. With further testing, however, the pressure and flow rate fell, and the operator cut the well back on a 7/64-in. choke. At last report, it was making about 250 bbl. per day with 3,200 psi. tubing-head pressure on the 7/64-in. choke.

The oil contains water ranging from a mere trace to 1 per cent. Salinity of this water — 16,000 p.p.m. — indicates that it is likely wash water.

What's ahead . . . Testing of the 21,443-ft. sand will go on until the well's owners are certain of its productivity.

If it's not good enough as is for final completion, there are several promising courses left.

First, more of the zone now producing can be perforated. There is a sand body 16-ft. thick above the perforated section and apparently separated from it by a shale break. Richardson & Bass intended to perforate this upper sand body too but the well kicked after the lower section was opened. For that reason, no further perforating attempts were made.

Well logs show other zones above the one being tested now. If the 21,443-ft. sand is not commercial, one of the higher sands may be.

Big point already proved . . . More important than establishing a new record is the proof that oil can exist in seemingly commercial quantities as deep as present tools will drill.

It may be that the reservoirs penetrated by the 1L Humble-L.L.&E.-State Lease 2414 will prove too small for the well to pay out. But there never again will be any question whether there is enough porosity and permeability at such extreme depths for oil to exist.

Geologists and engineers have speculated for years about just how deep oil could be found. The question was whether porosity would be "mashed" entirely out of the rocks by the weight of the overburden. Flow from Richardson & Bass' 21,443-ft. sand supports those who have held there is nothing to prevent oil accumulation in marine sediments at any depth they are known to exist.

Sixth time a charm . . . The sand now flowing in the wildcat is the sixth zone to be tested. It is the fourth below the previous depth record.

Richardson & Bass set a string of 7-in. pipe to 19,752 ft. And before drilling out from under that string, the company tested a zone at 18,500 ft. and a second at 19,050 ft. Either of these would have made the well the world's deepest producer. Both of these and two shallower zones were dry, so the operator drilled on to the record depth of 22,570 ft.

After setting 5-in. long string, Rich-

ardson & Bass perforated and tested a 100-ft. section below 21,500 ft. This thick sand appeared tight on the logs and the test confirmed this. Only a moderate amount of salt water was recovered from the section.

After squeezing these perforations (the deepest ever made), Richardson & Bass drilled out cement to 21,475 ft. and perforated the 21,443-65 interval. There is no packer in the well. Two-inch tubing hangs out of the christmas tree to a point 5 ft. above the perforations. Company engineers felt that the tubing could not be depended upon to withstand the bursting pressure that might result from opening an abnormal-pressure sand below 20,000 ft. The 5-in. long string should withstand the bursting load since it weighs 26 lb. per ft.

Two records in Louisiana . . . The well displaced as deepest ever to produce is a California well that made gas and condensate only a short time before being plugged back for a shallower completion.

This well, Richfield Oil Corp's 67-29 C.L.A. produced from Eocene sediments at 17,500-17,892 ft. It's location is only 10 miles from the Coles Levee 21,482-ft. test of Ohio Oil Co. that previously held the drilling-depth record.

Deepest current production is from a well of Shell Oil Co. in Weeks Island, La., field—only about 100 miles from the 1L Humble-L.L.&E.-State Lease 2414. Shell's 1 C.B. Patout makes gas and condensate from 17,558-84 ft. in a Miocene sand.

Offset is possibility . . . If continued testing shows the 21,443-ft. sand to be good enough for final completion, there's a good possibility that Richardson & Bass will drill an offset.

There's a nearby dry hole that reached 11,500 ft. in a 12¼-in. hole. It could be used as a starter for another test. Almost certainly, Richardson & Bass could drill a second well much cheaper and faster than the first.

The well also established other records for the drilling industry. Its string of 5-in. casing was the heaviest ever put into the ground. The 7-in. casing used only lacks 13 ft. of equaling the record of 19,765 ft. set in 1949 on a Wyoming well.

Cement jobs were the deepest performed with temperatures estimated at 340° F. Well logs run also were the deepest ever done. An electric log was successfully run to 22,570 ft., and a gamma ray-neutron log was run to bottom of liner at 21,809 ft.

In rich offshore "twilight zone" . . .

Louisiana Tilts with U.S. Again

BATON ROUGE.—Victorious in its latest skirmish with the U. S. Government over ownership of disputed offshore tracts, Louisiana now is trying for bigger stakes.

The Louisiana Mineral Board last week protested the Government's proposed leasing of thousands of acres under the Gulf of Mexico.

In a formal resolution, the board called upon the Government to abandon its call for bids on 104 tracts in the "twilight zone." The 104 blocks are among 152 which the Interior Department has offered to lease for oil and gas exploration May 15.

The state contends about 70 per cent of the acreage involved off the Louisiana coast is within the boundary claimed by the state. The federal Government recognizes Louisiana's claim to jurisdiction 3 miles from shore. The state claims its boundary is 3 leagues (about 10.5 miles) beyond the "coast line" separating so-called inland waters from the open sea.

The boundary dispute is now before the U. S. Supreme Court. A ruling is expected later this year.

Comeback . . . In its resolution, the Mineral Board said the federal Government's call for bids on disputed tracts was "a slander on the title of the State of Louisiana and injures its people and their property and property rights."

Leases offered by the Interior Department cover about 515,000 acres under the Gulf of Mexico. Of that total, 23,040 acres are off Texas and the remainder off Louisiana.

A similar situation arose last summer just before the Government's last offshore lease sale. At that time, Louisiana unsuccessfully protested the scheduled leasing of 29 tracts.

When the Government refused to withdraw its call for bids, Louisiana offered state leases on the same tracts the same day. On July 12, scheduled date of the conflicting sales, Louisiana failed to receive a single bid while the United States received more than $6,000,000 for leases in the disputed area.

Louisiana made a dramatic comeback earlier this month when it accepted bids totaling more than $8,000,000 for leases which the Government had protested *(The Oil and Gas Journal, April 23, page 81)*.

Escrow trouble . . . The state's failure to get any bids on disputed tracts last summer has been generally blamed on the lack of an escrow law permitting refund of lease money in case Louisiana loses its boundary battle. The federal Government permitted disputed funds from last year's sale to be kept in escrow pending a ruling on the boundary.

This year, however, the Interior Department has notified prospective bidders that accepted bids on disputed tracts will not be refunded when the boundary question is settled.

Dump Bidding Dumps Hopes

HOUSTON.—City councilmen are losing faith in Houston's chances of getting rich from oil which they hope will be found under a city garbage dump.

The city last week received only one bid for a lease on the 300-acre dump, which is about 500 ft. east of nearest production in the extremely active Pierce Junction field *(The Oil and Gas Journal, April 23, page 79)*. The lone bid, submitted by Trice Production Co., Longview, Tex., was a $25,200 cash bonus.

Lack of interest in the property stunned expectant councilmen. Thirty-six companies and individuals, including several major operators, had taken out bid specifications.

Some city officials had publicly predicted that the city eventually might receive $20,000,000 or more in bonus and royalties.

The council deferred action on the Trice bid.

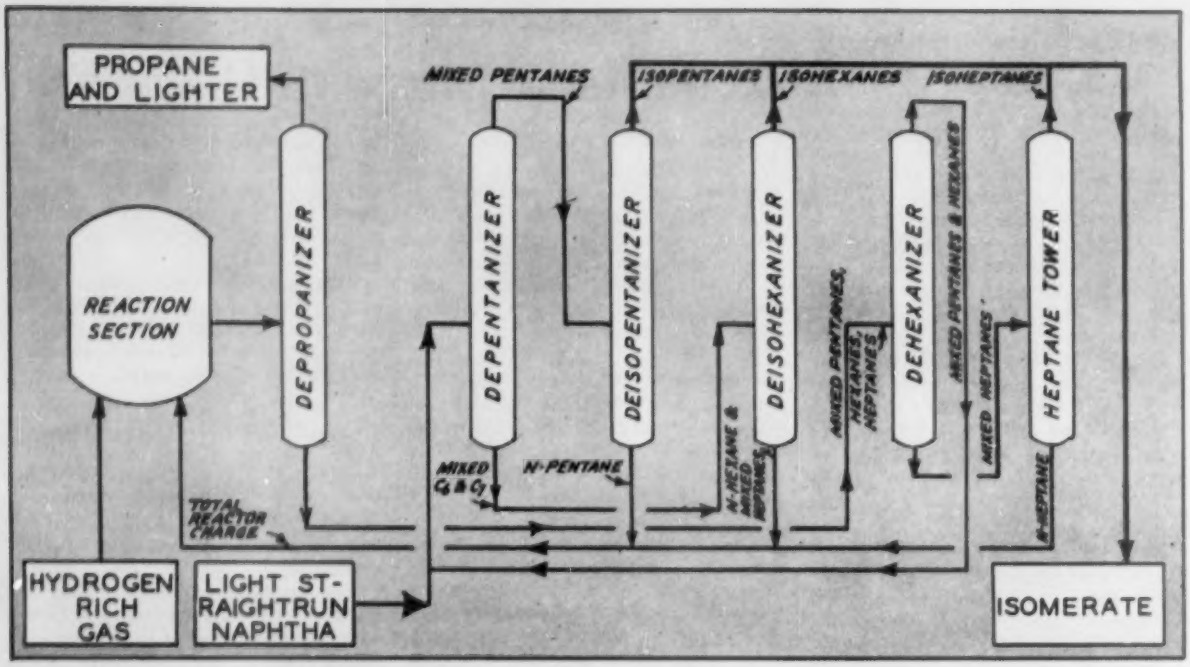
"I think someone down the line is trying to get to the city," lamented one official.

Compact Study Favored

WASHINGTON.—The House appropriations committee recommended last week that the Justice Department be given the money it asked for an all-out investigation of the working of the Interstate Oil Compact.

The study would require the services of 110 people and cost well in excess of $500,000, according to information given the committee by Asst. Atty. Gen. Stanley Barnes, head of the anti-trust division.

The committee approved Barnes' program with but one qualification. Barnes said two or three offices might have to be set up on the Gulf and West Coasts for the study. The committee, insisting the offices should be temporary, wrote a clause in the bill that the department could not set up any permanent regional offices.



New Process Expands High-Octane Pool

CLEVELAND.—The Isomerate process which made its bow here last week offers the refiner a valuable tool for upgrading less desirable feed stocks into high-octane gasoline components.

Developed by Pure Oil Co.'s Research and Development Laboratories at Crystal Lake, Ill., it promises to bring more light refinery naphtha, natural gasoline, or light catalytic reformate into the high-octane pool. The new hydroisomerization technique has now been made available for licensing by the industry.

Isomerate differs from various other isomerization processes on the following points:

... **It will convert** not only straight-chain pentane and hexane, but also normal heptane, to high-octane branched-chain isomers.

... **It will use a rugged** non-noble metal catalyst which will be available from commercial sources. Exact nature of the catalyst has not yet been revealed.

... **It employs no corrosive** elements and the catalyst can be regenerated in place, when necessary.

... **Operating conditions** are relatively mild, and isomer yields of 95 per cent or higher are obtained.

... **Through the prefractionation** of feed stocks and separation and cycling of normal paraffins to extinction, isomer yields closely approaching equilibrium distribution are obtained.

Arthur G. McKee & Co. of Cleveland has contracted with Pure to design commercial units for the new process. McKee engineers are now preparing economic studies and are ready to provide estimates on yields, capital, and operating costs for units charging a variety of feed stocks.

Octane breakthrough . . . The growing importance of isomerization as the principal remaining technique for upgrading light naphthas has led to its inclusion in future processing plans by many refiners. Results from Pure's laboratory runs illustrate why.

In processing a light deisopentanized gasoline with a 200° F. end point (including heptanes), isomer yields approaching 100 per cent are obtained. The charge stock with a 64.4 clear research number is upgraded to product rating 96.5 to 97.5 octane number with 3 ml. of TEL, by both the research and motor methods.

The high motor-octane number typifies branched-chain paraffins. In most cases, Pure reports, the isomerates produced in their pilot plant runs have shown negative sensitivity—with motor octanes rating higher than research. Road ratings obtained in commercial vehicles also compare favorably with research octanes. In an extensive road-testing program, Pure has found that isomerate-reformate blends of gasoline of 97.5 research octane number show actual road ratings equal to or exceeding catalytic cracked-reformate gasolines of 100 research octane number.

While pentane and hexane isomerization entails well-known advantages, Pure emphasizes the further benefits of heptane conversion. Normal heptane, assigned a rating of zero octane on the conventional scale below 100, has been recognized as a coming problem in the move toward higher octanes. Pure's Isomerate process is the first to be announced for commercial upgrading of this component of isomerization.

By comparison with catalytic reforming, which is admittedly better equipped to handle heavier naphtha fractions, the new process shows definite advantages. A straight C_7 fraction containing 27 per cent of naphthenes, when isomerized and reformed to the same leaded research number, shows the following yield and sensitivity gains from the former process:

	Isomerate	Reformate
Yield, vol. per cent	95+	77
RON + 3 ml. TEL	92+	92+
Motor ON + 3 ml. TEL	92	85
Sensitivity	0	7

This comparison supports the contention that light catalytic reformate in the C_5 to C_7 range makes admissable feed stock for the Isomerate process. This promotes its potential usefulness in further upgrading light catalytic re-

formate. The further addition of natural-gasoline and cycle-product fractions in the same boiling range would permit use of larger units at a lower cost per barrel processed.

Process Conditions . . . The Isomerate process will perform at fairly mild conditions, with temperatures of less than 750° F. and pressures lower than 750 psig.

Lowering the operating temperature permits higher yields of branched-chain isomers. Hydrogen is recycled to the fixed-bed reactor to improve activity and selectivity of the catalyst. The process uses no corrosive elements, Pure says, and long catalyst life and equipment service is expected.

Feed stock with low isomer content can be processed without prefractionation. But the normal operation is expected to include separation and recycling of normal pentane, hexane, and heptane from both the feed and reactor effluent. For this type of operation, the fractionation section will account for the major cost of a new unit.

As shown in the accompanying flow chart, feed stock and mixed reactor effluent are continuously fractionated. Straightchain components are recycled to extinction and the overhead streams from the three splitter columns comprise a high isomer content. The fractionation section is designed to give a practical degree of separation. It avoids the complexity and high cost required for precise cuts, at the same time eliminating enough of the isoparaffins from the recycle stream to permit good equilibrium conditions to prevail in the reactor.

It is likely that a high percentage of Isomerate units to be built in the future will be closely integrated with catalytic reformers, since they can upgrade the light catalytic fraction which may average 25 per cent of total reformate. Integration will also provide reformer hydrogen required in the isomerization step and can reduce capital and operating costs.

Unit costs have not been revealed publicly, but McKee is prepared to quote yield and cost data, given pertinent feed-stock characteristics. It is believed that a 5,000-bbl. per day unit can be built for about $500 or less per barrel of daily capacity.

Blow Dealt Defense Crude Line

WASHINGTON.—The idea of federal aid for a national defense crude line from the gulf to the East Coast received what may be a death sentence last week.

The 1,000,000 bbl. daily which would have to move overland to East Coast refineries if tanker transportation were cut in an emergency can be provided through present facilities and the conversion of the Big Inch gas line, Mobilization Director Arthur S. Flemming was told in a staff report.

On that basis, government loans or guarantees are "not justified," Flemming's aides stated.

The recommendation, if accepted by Flemming, could kill plans of American Pipeline Corp. and Texas Eastern Transmission Corp. to provide lines from the Gulf Coast to the Ohio-Pittsburgh area. Both proposals called for government backing of loans.

The report also is seen as ruling out government aid for a line from West Texas to California.

Flemming sent the staff report along to the parties who took part in a hearing last September 12. He gave them until May to file their comments "before acting on the recommendation."

The background . . . The idea of a Gulf-East Coast line was advanced early in 1953. The Defense Department and Petroleum Administration for Defense agreed that provision should be made against the possible cutting of East Coast tanker supplies, before such an emergency arose.

They also agreed the crude should be assembled in the Ohio-Pittsburgh area.

How to do it was a difficult question. Several different ideas were advanced. One was for government construction of a line. A second called for the purchase and stockpiling of line pipe and equipment. Another was that the line be built privately with government help. It was on that basis that American and Texas Eastern offered their proposals.

Supply better . . . The ODM report was based on a new study by Interior's Office of Oil and Gas.

It shows that crude-line capacity into the Ohio-Pittsburgh area is now 665,000 bbl. daily.

Building of the Arapahoe and Butte lines, and expansion of Service, Lakehead, and Interprovincial lines have added capacity, it said.

The 335,000 bbl. daily of Gulf Coast oil needed to meet the 1,000,000-bbl. emergency requirement is what American and Texas Eastern proposed to supply. But conversion of the Big Inch gas line would fill that need, and the Government has reversion rights on this line until 1967.

Processing BRIEFS

MOOSE JAW, Sask.—Husky Oil & Refining, Ltd., has started routine operation of the new 600-bbl. per day Catforming unit at the 3,000-bbl. refinery here. The unit processes a full boiling range, untreated Fosterton crude naphtha to produce a 95-octane Catformate. Like a similar unit completed last year at Husky's Fort William refinery, the new catalytic reformer was built by Fluor Corp. of Canada and is licensed by Atlantic Refining Co.

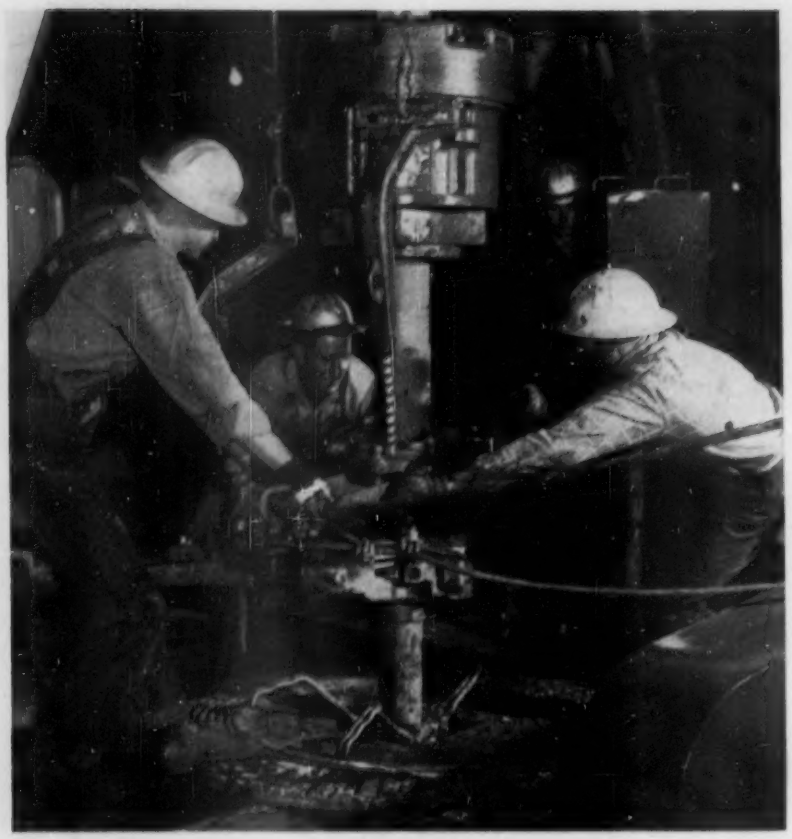
MARCUS HOOK.—Sun Oil Co.'s 300-ton ammonia plant will be back on stream sometime this summer, probably by early August. An explosion in the air purification section touched off hydrogen in the nearby hydrogen unit, and heavily damaged the plant's control room. Estimates of damage run less than $3 million on a total cost of $10 million for the installation, which was completed late in January.

MONTREAL.—Imperial Oil, Ltd., is spending an additional $2,000,000 here for maintenance and other improvements to the newly enlarged 65,000-bbl. per day refinery. About half of the new investment will go into a central maintenance building measuring 200 by 350 ft. Other improvements will be made in asphalt manufacture and shipping, tankcar loading facilities and a new cooling tower. A current $5,000,000 processing program includes the construction of a 9,000-bbl. per day Powerforming unit.

BISHOP, Tex.—Celanese Corp. of America will add new petrochemical facilities here to boost output of formaldehyde, methanol, acetaldehydx, and other organic chemicals by 25 per cent. With initial operation due in 1957, the expansion project will make the Bishop plant the largest formaldehyde producer in the world.

NEW YORK.—The Texas Co. will build a refinery in the Pacific Northwest, but company officials are not saying exactly where until purchase has been made of all the acreage needed. For the past several months, Texaco has been obtaining options on tracts in the Puget Sound area.

BATON ROUGE.—Ethyl Corp. is looking further into petrochemicals. A new half-million dollar addition to the research laboratory will permit further work on petrochemicals, chlorination, organometallics, and electrochemistry.



There's talk but no action on . . .

. . . Shorter Week for Rig Crews

W. A. Bachman

THERE'S plenty of talk for shortening the work week of drilling crews.

So far little has been done about it. And this much appears certain: Contractors will have to get a price hike in footage and day rates if it comes this year.

Leaders in the oil-drilling business nearly to a man agree the shorter work week is needed. They think it's a shame that rig crews have to work 7 days a week in the oil patch. They predict shorter hours will come eventually.

But here's what they face now in any switch to a 40, 42, or 48-hour week:

. . . **Costs.** It would mean a 30 per per cent increase in a contractor's labor bill and would come at a time when he is battling cutthroat competition in drilling-price rates.

. . . **Shortage of manpower.** It would likely mean adding a fourth crew on most rigs at a time when experienced drilling personnel is hard to come by.

. . . **Workers' uncertainty.** If shorter hours mean a big cut in pay, rig crewmen want no part of it.

In all areas except California, they now work 56 hours per week, getting time and one-half pay for the 16 hours in the extra 2 days. Nearly half their pay check is made in the sixth and seventh days. A big jump in the hourly pay rate would have to accompany the cut in hours to make it palatable to the men.

Why the talk . . . The drilling industry realizes it's in a vulnerable position with a 7-day week while most other American industry is on a 5-day basis.

Union agents generally have had little luck in organizing the drilling segment of the oil industry. But there are reports of stepped up union activity in West Texas among drilling crews.

One contractor acknowledges the chief pitch labor unions now can make to their men is a shorter work week for the same pay. Another union talking point is greater bargaining power for more fringe benefits and future pay raises.

But most drilling contractors feel the key to any union encroachment on the oil patch is the 7-day week. They would like to remove the sore spot before union agents can capitalize on it.

The contractors also have other incentives for studying a shorter week. These include:

. . . **Recruiting troubles.** Contractors are finding themselves in a poor bargaining position for attracting more capable rig hands because of the long work week.

. . . **Morale.** The 7-day week is hard on families of the men. Drilling hands see a neighbor pack off his wife and kids for a weekend trip or spend 2 days loafing at home. The drilling crew worker packs off to the oil field and usually works straight through without days off while the rig is making hole.

. . . **Outside pressures.** Contractors report they often are asked by officials of major oil companies how they get by working crews 7 days per week. There is a growing awareness of the unpopularity of the long week.

What's being done . . . Drilling industry representatives are quick to point out the 7-day week has its compensations. They also emphasize that industry leaders are studying plans to shorten the work week without bankrupting the contractors.

Some contractors report their crews are not unhappy with their hours. The men want to work all they can when a job is available. Figuring in downtime for moves, cementing, and other idleness, they now average working about 42 hours a week. The 2 days of overtime they get each week make their paychecks respectable. None of the men wants to take a cut in total pay to win a shorter work week.

California contractors already work a shorter week. They use four crews on a rig and work them 6 days with 2 days off. This arrangement results in the crews getting 2 days off each week for 6 weeks. They work 7 days in the seventh week with overtime and then return to the 6 days on, 2 days off routine.

California pay scales, however, are higher than those paid in the rest of the nation. Pay for floormen will average $2.60 to $2.70 with tool pushers and drillers drawing about $3.85. Wages in the Mid-Continent range from about $1.90 for floormen to $2.50 for tool pushers.

There have been a few moves to shorten work week in other areas. One West Texas contractor has cut the size of his crew to four men in order to give his workers extra days off. One major oil company which has several of its own rigs experimented with the shorter week. Its officials privately said the test was a failure. The men didn't

go for it. They complained of the shorter crews which made work harder on deep wells and also didn't like the smaller gross pay. The company returned to a 7-day week.

A committee of the American Association of Oilwell Drilling Contractors last year recommended the industry shorten its work week to 40 or 48 hours. The issue was blocked before ever coming to a vote. Smaller contractors claimed such a move would ruin them because they hadn't recovered from the last two wage hikes given their workers. They estimated the shorter work week would add $80 to $90 per rig day to costs for less work.

Another move may come before the A.A.O.D.C. this year for the shorter week. If so, it will be accompanied by a proposal to agree on a standard drilling contract containing a labor escalation clause. Under this clause the operator would agree to reimburse the contractor for higher wages he must pay if an industry-wide pay increase is granted during drilling operations.

What's involved . . . Drilling contractors say they will not shorten the work week unless they are sure they can pass the added cost on to the operators.

It's estimated the shorter week would add 30 per cent to their costs. Contractors say they can't absorb that much without going out of business. Many big contractors report their profit margins have dropped dangerously in the last 2 years. Some smaller firms admit they're fortunate these days to wind up the year with rig-depreciation funds left. All agree if any radical change is made in the drilling work week the operators will have to foot the bill.

Contractors report it's already hard to get good crews. A shorter work week would mean adding either an extra crew or extra crew members. That would only add to the manpower troubles.

In California, contractors employ four crews on the equivalent of a 42-hour week. Often they use 4-men crews on wells no deeper than 7,000 ft. On deeper wells 5-men crews are used. If the industry should change to a 48-hour week, it would mean three crews with the equivalent of 3½ men swinging through the crews to work the days off. A 40-hour week would mean four crews with the equivalent of 1½ men swinging.

It all adds up to more men on the rigs and higher hourly wages because none favor a pay cut.

One contractor summed up the attitude of most. He said, "The shorter week is coming some day. But if it comes this year, it would put me out of business unless I got higher footage or day rates."

watching WASHINGTON

. . . with Bertram F. Linz

Railroads looking hard for fuel economies . . .

SOMETHING new in the way of diesel locomotive fuels may be in the making, designed by the railroads themselves.

A major southeastern carrier is testing new blends in a standard 1,000-hp. engine. It's a real scientific job. The engine is bolted down in a test room and wired to all sorts of electronic recorders so the operating characteristics can be studied.

Photos of a cathode-ray oscilloscope screen show the engine's "heart" action. They give a permanent record of ignition lag, point of peak pressure, maximum pressure, fuel-injection timing, and burning rate of fuel. Other instruments record the temperature of water, lubricating oil, and the exhaust gas stream.

The tests are aimed at finding out what fuel oils blend best in railroad locomotives to give maximum efficiency. At the same time, studies are being made of the life of lubricating oil under operating conditions.

It's all part of the railroads' drive for operating economies. It costs $150 to $200 to make a change of lubricating oil in a diesel, for instance. The railroads have some 30,000 locomotive units. Cutting the number of oil changes yearly could save considerable money.

Oil's import-relief umbrella lures others . . .

THE national-security clause written into the Trade Agreements Act last year to kill a demand for quotas on oil imports is being invoked by a number of other industries.

Formal relief requests for seven products have been filed with the Office of Defense Mobilization. Others reportedly will be sent in soon.

Only in the case of oil has it been possible to try to meet the situation by "voluntary" import controls. Relief for producers in other lines will have to come by formal action, and ODM has set up the method for studying applications.

The law provides that the director of ODM advise the President when he believes that any article is being imported in such quantities as to threaten the national security. The President then can order an investigation to learn whether higher tariffs or quotas are necessary. Thus, in effect, two investigations are required—the first to see if the second is necessary.

ODM's investigation is the first definite step announced by the agency since the law was passed last May.

The administration is opposed to high tariffs or import curbs. ODM has been trying for nearly a year to get agreement by the importing companies to cut oil imports to the level recommended by the cabinet fuels committee in February 1955. Domestic producers would like to have the situation aired in public hearing. They are confident that once the facts are on public record, formal control would be inescapable.

Rising capacity halts quick write-offs . . .

THE domestic refining industry will have a capacity of 9,000,000 bbl. daily by next January 1.

That's the final goal of the Government's expansion program for the industry, started in 1951. The original target was 8,000,000 bbl. It was raised to 8,750,000 bbl. in 1953 and again to 9,000,000 bbl. last year.

Mobilization Director Arthur S. Flemming is closing the program. There are enough applications for quick write-off of new plants to meet the goal, and no more will be accepted.

To meet the Government's desire for a 9,000,000 bbl. capacity, the industry threw some $2,500,000,000 into the pot. Up to the end of last month 546 projects had been certified by the Office of Oil and Gas. The total investment given quick write-off was $2,162,000,000. That does not include land or facilities not allowed accelerated amortization.

How Much It Costs to Stay in Business			
	1944	1948	1953
Income from production ($ millions)	2,011	5,044	6,471
Total expenditures ($ millions)	2,123	3,841	6,448
% of income reflected in expenditures	105.6	76.1	99.6
% of income expended for exploration, development	74.4	52.1	67.6

Second economic study shows . . .

. . . Oil Men Investing in Future

THE oil industry, despite skyrocketing costs of doing business, is continuing to plow back tremendous outlays of capital for expansion.

These dramatic facts are revealed in a special survey made jointly by the American Petroleum Institute, the Independent Petroleum Association of America, and the Mid-Continent Oil and Gas Association.

The survey pinpoints these highlights:

. . . **Exploration and development** outlays in 1953 totaled 67.6 per cent of oil industry income.

. . . **Expenditures for all purposes** were 99.6 per cent of income in the same year.

. . . **Costs of exploration,** development, and production more than doubled in a decade.

. . . **Income from gas** is becoming a greater factor in industry receipts.

The study published last week is the second and final part of research started 16 months ago by the three associations. They had one aim: To develop specific information on drilling and production costs. This never has been compiled on an industry-wide basis. As a result oil men who knew their own operating costs in outline had no specific facts on long-term trends for the industry.

The first report was published in January *(The Oil and Gas Journal, January 30, page 124).* It covered drilling costs. It showed that oil men spent an average of $50,000 in drilling and equipping each of the 49,279 wells drilled in 1953. Also emphasized was the astronomical way in which drilling costs have shot up as depths increased.

Statistics in the second report, like the first, cover up to 1953. They are the most up-to-date available. Costs and other factors may have increased since. But the survey is intended to give specific information over a 10-year period where none existed before.

Big spending . . . Oil industry expenditures in 1953 averaged $3.16 for each barrel of net crude oil produced.

This was a big increase from 10 years earlier. Spending in 1944 averaged $1.47 a barrel and $2.21 a barrel in 1948. The spending per barrel increased 50.3 per cent between 1944 and 1948, and 43 per cent between 1948 and 1953, and 115 per cent between 1944 and 1953.

Broken down and costs revealed this picture:

. . . **Production spending** went from 43 cents per barrel in 1944 to 70 cents in 1948 and $1.02 in 1953.

. . . **Exploration outlay** went from 45 cents a barrel in 1944 to 64 cents in 1948 and 95 cents in 1953.

. . . **Development spending** rose from 59 cents a barrel in 1944 to 87 cents in 1948 and $1.19 in 1953.

The associations stressed that these expenditures only cover total operations of the petroleum-producing branch, including gas. They represent cash outlays and often investments in the future rather than expenses as recorded by accounting practices. They do not include spending for such items as income taxes, payments of interests and principal on debts, or returns to investors.

The estimates of total expenditures by all operators engaged in petroleum production were:

EXPENDITURES
(Million dollars)

	1944	1948	1953
Exploration:			
Dry holes	274	462	797
Other*	327	570	987
Overhead	44	79	172
Total	645	1,111	1,956
Development:			
Producing wells	593	1,058	1,762
Equipment	203	362	483
Overhead	55	98	174
Total	851	1,518	2,419
Production:			
Lifting cost	566	1,097	1,846
Overhead	61	115	227
Total	627	1,212	2,073
Total expenditures	2,123	3,841	6,448

*Lease purchase, lease rentals, geological and geophysical work, etc.

Income . . . Oil operators during the 10-year period also showed a gain in income.

United States petroleum production brought in revenues of $2.011 billion in 1944, $5.044 billion in 1948, and $6.471 billion in 1953. This was equivalent to $1.39 per barrel of net crude oil produced in 1944, $2.90 per barrel in 1948, and $3.17 per barrel in 1953.

The revenue broken down by source for the decade shows:

(Million dollars)

	1944	1948	1953
Crude oil	1,746	4,517	5,464
Natural gas	163	288	668
Royalty owned by operators	93	266	319
Other lease income	9	13	20
Total	2,011	5,044	6,471

Trends . . . Several important trends are noted in the relation of spending to income.

Total expenditures in 1944 were 105.6 per cent of income. They were 76.1 per cent in 1948 and 99.6 per cent in 1953. The percentage of income devoted to exploration and development fluctuated from 74.4 per cent in 1944 to 52.1 per cent in 1948 and back to 67.6 per cent in 1953.

The explanation is this. In 1944 the producer had a low, stable price and high expenditures. He was reinvesting a high percentage of his income in the business. Then in 1948 income jumped as a result of some price increases. The percentage of income reinvested fell largely because of the steel shortage, especially in tubular goods. This

prevented expansion and curtailed exploration. But in 1953, while income rose only slightly over 1948, the percentage of reinvestment shot back up.

Another development in revenue was the growing importance of natural gas. In 1944 natural gas brought in only $163 million. It rose to $288 million in 1948 but by 1953 totaled $668 million. This improvement has been far greater than in the case of crude.

But whether the operator gets oil or gas, one fact was emphasized by the survey. He has to keep pouring a big part of his revenue into finding more oil if he wants to stay in business. Often to do this he has to supplement income by borrowing or new equity financing in order to pay for the big spending.

Peace River Plant

Pacific Petroleums will build gas-processing unit

CALGARY. — An $18-million, gas-processing plant—the first in British Columbia—will be built by Pacific Petroleums, Ltd., to handle Peace River area gas.

The plant will extract 250 to 300 tons of sulfur a day initially, in addition to removing all natural-gas liquids. It also will be designed to produce motor gasoline and aviation gasoline, according to a company announcement.

Residue gas will go into the Westcoast Transmission Co. pipeline to Vancouver now under construction.

The big plant will be located near Fort St. John on the north bank of Peace River. Construction contracts have been awarded to Marwell Construction Co. of Vancouver and Stearns-Roger Manufacturing Co. of Calgary. Completion date is set for "sometime in 1957."

Pacific Petroleums' president, George L. McMahon, hailed the plant as "an entirely new industry for British Columbia" and a possible "forerunner of a new chemical industry for the province."

It is one of the first petroleum-industry operations to be announced since construction was started on the 650-mile, 30-in. Westcoast pipeline, which will have a capacity of 660 million cubic feet a day *(The Oil and Gas Journal, January 30, page 133)*.

The line will run to a point near Sumas, Wash., where it will hook up with Pacific Northwest Pipeline Corp.'s line from the San Juan basin.

Westcoast expects its line to be serving Vancouver by the end of the year and the U. S. Pacific Northwest by September of 1957.

It's rough sea in Congress as . . .

. . . Navy Drilling Plan Opposed

WASHINGTON.—The Navy's plan to drill for oil on San Nicolas Island off the coast of California is meeting stiff resistance in Congress.

A Navy request for $529,000 for a core hole and test well may lead to a demand that Congress interpret the law under which the naval petroleum reserves are administered.

Department officials contend that Congress, in the law and in later urgings to go out and find new reserves, gave the department the right to drill on any land it may control. Some congressmen, notably those from California, assert that it has the right to drill only on formally designated naval reserves.

Announcement of the Navy's plans to drill on San Nicolas and set the island aside as a reserve if oil is found brought strong protests from California oil interests. The protest led to a hearing on the matter by the House Interior committee, headed by Rep. Clair Engle of California.

Capt. A. S. Miller, director of naval petroleum reserves, told the committee that in general all designations of areas for naval purposes in effect give the Navy fee simple title. The department has the authority to drill for oil in such areas under existing law, he said.

The request for funds is pending in the House appropriations committee. Engle and other California congressmen indicate they will urge the committee to deny the money.

Equipment Suppliers Elect Elliott

BOCA RATON, Fla.—Rainey Elliott, president of the Supply Division of Jones & Laughlin Steel Corp., was elected president of Petroleum Equipment Suppliers Association at the group's twenty-first annual meeting here.

He succeeds M. E. Montrose, vice president of Hughes Tool Co., Houston.

Grover Kilgore, vice president of Halliburton Oil Well Cementing Co., Duncan, Okla., was named vice president.

MONTROSE

KILGORE

RAINEY ELLIOTT
. . . New president of P.E.S.A.

The association released figures compiled in a survey by the Business and Defense Service Administration which show:

. . . **An 18 per cent** dollar increase in products and services sold to the producing-drilling segment of the petroleum industry in 1955. Total sales were $1,096,599,858. About 18 per cent of this went for well-servicing equipment.

. . . **A big increase** in the use of raw materials. In 1955, the industry's consumption of carbon steel was 526,190 short tons—up 10 per cent from 1954. Usage of alloy steel jumped 22 per cent to 248,294 tons, and stainless steel, both nickel and nonnickel bearing, increased 121 per cent to 11,878,000 lb.

District chairmen elected at the meeting were John Staudt, executive vice president of Dowell Incorporated, Tulsa, Mid-Continent and Rocky Mountain district; Paul Scherf, general manager of Alten Foundry & Machine Works, Lancaster, Ohio, eastern district; M. E. Montrose, southwestern district; and W. T. Powell, president of Emsco Manufacturing Co., Los Angeles, Pacific district.

H. R. Safford, Jr., Houston, was re-elected executive secretary.

Geologists Handed Challenge

Jersey's Knebel tells exploration men what must be done if reserves are to be found to satisfy demand of future

CHICAGO. — American oil finders last week were charged with four major responsibilities for the future.

They must be met if we are to find the necessary oil reserves both here and abroad, delegates to two conventions were told by G. M. Knebel, exploration manager of Standard Oil Co. (N. J.) and out-going president of the American Association of Petroleum Geologists.

Knebel addressed the A.A.P.G. and Society of Economic Paleontologists and Mineralogists. He outlined a program calling for:

. . . A broadened point of view. This is the geologist's most urgent need, he said. "The world for which we must provide energy is growing faster than many of us realize and its thirst for oil is growing at an even greater rate," Knebel declared.

"Increases of such magnitude add up to a task which we, in our profession, will have to think out and work out on a world-wide basis. Provincial points of view will have to be put aside."

. . . Stepped-up research. Knebel called for added emphasis on correlation and dating of crude oils, a systematic cataloguing of all known facts about the habitat of oil, comprehensive paleogeographic maps of the U. S., and a means of identifying oil source beds.

Other fields for research, he added, are in recharging depleted fresh-water reservoirs, the habitat of faults in sedimentary basins, and the reasons certain formations in the geologic column produce heavily all over the world while others are barren.

. . . Reversal of the trend away from science education. "We must recruit manpower intensively if sufficient oil is to be found for tomorrow's world. . . The number of geology students has dropped every year, and last year it fell 10 per cent. Our profession is on the way out right before our eyes unless we halt this trend."

. . . Good-will ambassadors abroad. If the geologist, as advance representative of oil companies, makes the right first impressions, "he invites respect, rather than hostility, for the things he stands for, and toward the conditions which must prevail if private enterprise is to do business."

Knebel yields the presidency of the A.A.P.G. to Theodore A. (Ted) Link (see page 275).

G. M. KNEBEL
. . . Provincial viewpoints put aside.

S.E.P.M. address . . . In his address as president of S.E.P.M., F. J. Pettijohn of Johns Hopkins University, admonished exploration men to dust off their hammers and alidades.

"It has often been said," he told them, "that there are three kinds of geology . . . field geology, laboratory geology, and theoretical geology, or, in the vernacular, outcrop geology, sample geology, and armchair geology.

"In reality, there is but one kind, namely, geology; and to divorce field study from laboratory and library work is both unrealistic and sterile." He said company research "is in as much danger of losing touch with reality as is that of some universities. Nothing . . . is so sobering as an outcrop. And many a fine theory has been punctured by a drill hole."

William E. Wrather, retiring director of the U. S. Geological Survey, Washington, D. C., received the Sidney Powers Memorial award from the A.A.P.G. The award is the highest in the field of earth science.

Turnpike Rights to Conoco

AUSTIN.—The Texas Turnpike Authority is expected to accept Continental Oil Co.'s high bid for exclusive service-station rights on the projected Dallas-Fort Worth turnpike, due for completion July 1, 1957.

Continental offered 8.105 cents a gallon on gasoline sales and 10 per cent of revenue from other merchandise or services. The minimum payment is to be $45,000 annually under a 5-year contract. Conoco will operate two stations which will be built by the authority.

Other bidders were: Sinclair Oil & Gas Co., 7.93 cents a gallon; Phillips Petroleum Co., 7.012 cents; and The Texas Co., 4.53 cents.

Petrofina Moves

Belgians form U. S. firm, will buy Panhandle stock

NEW YORK.—The fast-moving Belgian oil group, Petrofina, launched itself in the United States last week with the avowed purpose of becoming another major integrated oil company in this country.

Stockholders of Panhandle Oil Corp. approved a proposal to increase its authorized stock from 2½ to 10 million shares and at the same time sell Petrofina 600,000 shares of stock at $11.25 a share.

Petrofina has an option to buy another 270,000 shares at the same price within 3 years. This would give Petrofina control.

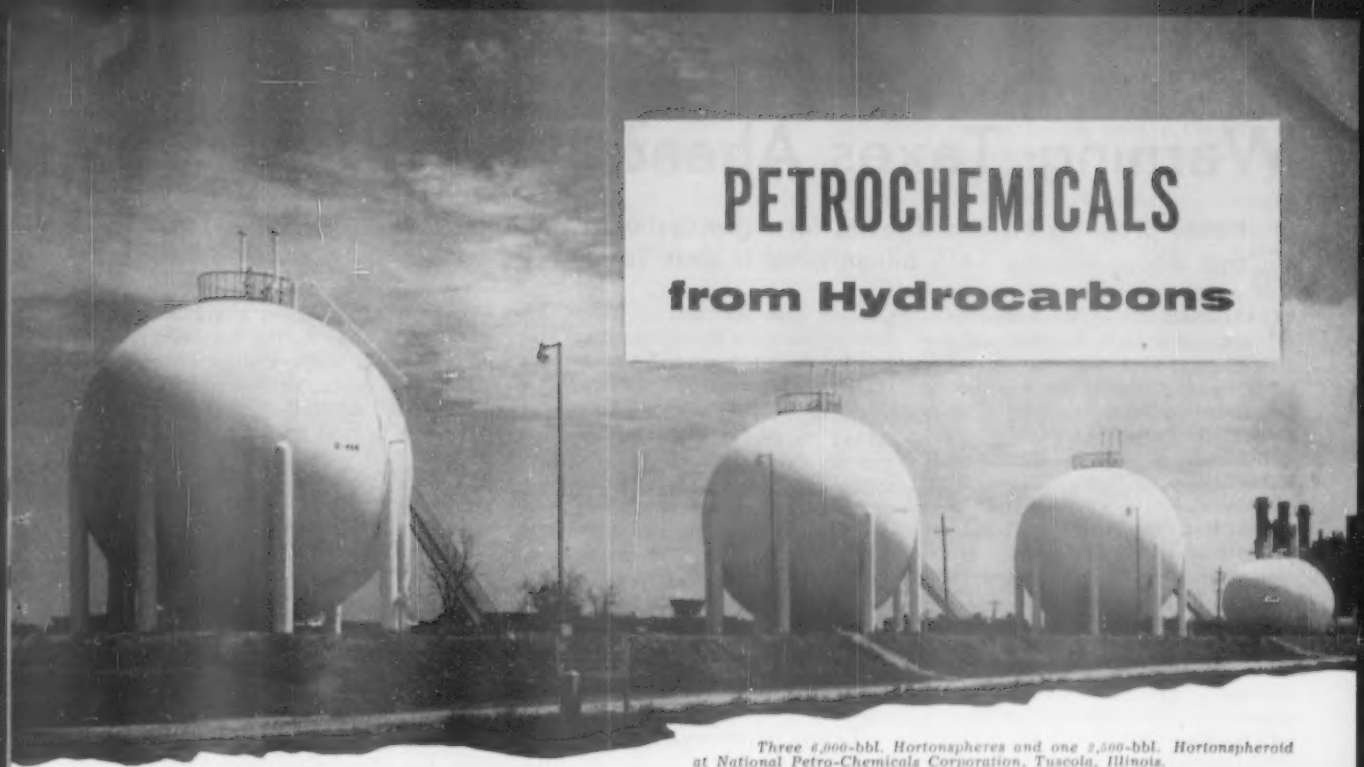
The Panhandle stockholders followed the recommendation of their board of directors just a few days after the incorporation charter for American Petrofina, Inc., was filed in Delaware.

There's more to come . . . Petrofina regards Panhandle, with its 3,100-bbl. daily crude production, 8,000-bbl. daily refinery at Wichita Falls, Tex., and its marketing outlets as merely the vehicle for its ride into the United States.

The Belgian firm is actively looking for additional producing properties in this country. It probably will make a public stock offering in the new American company as soon as it locates property to buy.

The new American Petrofina is being initially financed about 80 per cent by Cie. Financiere Belge Des Petroles, S.A., the parent Belgian firm, and 20 per cent by the still youthful Canadian Petrofina.

Directors slated to be elected for American Petrofina include L. B. Wolters, vice president of the parent Belgian firm, chairman of the board and president; W. D. Heath Eves, who has been acting as Petrofina's American representative, executive vice president; Alfred Camp, executive vice president; Howard Marshall, vice president of Signal Oil & Gas Co., a director; Roger Gilbert, Panhandle president, a director; and G. Peter Fleck, representative of Belgian banking interests, a director. A seventh director is scheduled to be elected later.

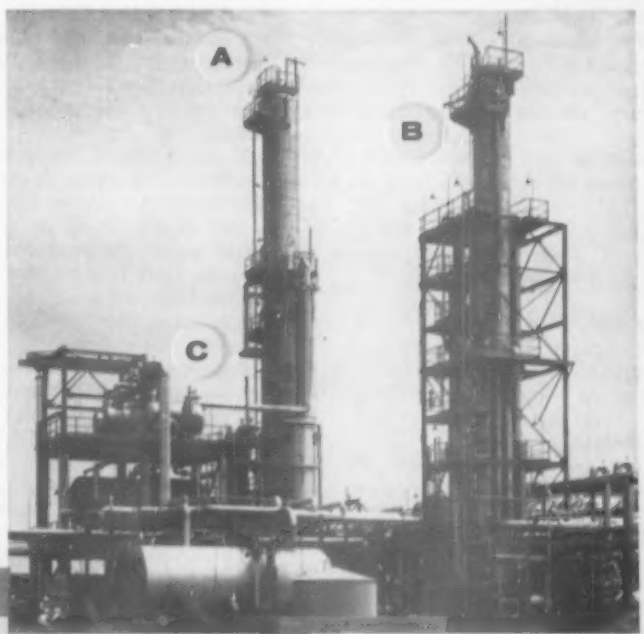


Three 6,000-bbl. Hortonspheres and one 2,500-bbl. Hortonspheroid at National Petro-Chemicals Corporation, Tuscola, Illinois.

. . . another job that demands expertly engineered tanks and towers

. . . and CB&I has complete facilities to engineer, fabricate and erect them all. Four strategically located plants can provide solid, lined or clad steel structures built to the most exacting specifications. The towers, Hortonspheres® and Hortonspheroid® shown here, built for that brawny "infant" industry of petrochemicals, were fabricated and erected by CB&I for J. F. Pritchard Company and the Lummus Company and are located at the National Petro-Chemicals Corporation, Tuscola, Illinois.

Write our nearest office for further information on expertly engineered steel plate structures by CB&I . . . from tanks to towers.



A 6½-ft. diam. by 73-ft. stripper tower.

B 5½-ft. diam. by 88½-ft. absorber tower.

C 6½-ft. diam. by 20-ft. accumulator tanks.

CB&I

Chicago Bridge & Iron Company

Atlanta • Birmingham • Boston • Chicago • Cleveland • Detroit • Houston
Los Angeles • New York • Philadelphia • Pittsburgh • Salt Lake City
San Francisco • Seattle • Tulsa
Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY *and* GREENVILLE, PA.

Warning: Taxes Ahead

House proposes increased levies for highways that will cost motor industry 14½ billion more in next 16 years

WASHINGTON. — Motorists, truckers, and intercity bus lines will pay an additional $9.5 billion in motor-fuel taxes over the next 16 years as part of their contribution to the cost of modernizing the nation's highways.

They will pay another $5 billion in higher taxes on vehicles, tires, and camelback.

That is the big news from the House public works committee which favorably reported out the new highway construction bill last week.

The increases will be tacked on to the $40.9 billion which the present taxes, plus those on lubricating oil and automotive parts and accessories, are expected to yield between next July 1 and June 30, 1972.

The total automotive tax bill over the period will be $55.8 billion. But only part of this will be used for highways. The taxes on motor fuels, tires, and tubes have always been earmarked for that purpose. Added to the increases on vehicles, they will raise $38.5 billion. That will cover the federal Government's $37.9 billion share of the $51.5 billion road program.

The additional gasoline revenue will be raised by a "temporary" addition of 1 cent per gallon to the present "temporary" addition of ½ cent to the "temporary" 1.5-cent tax adopted nearly a generation ago. The two "temporary" increases will automatically expire June 30, 1972—so the committee said. The tax on diesel fuel will be similarly increased. There will be no increase in the levy on lubricating oils.

Use rate rising . . . Over the 16 years for which taxes are estimated, fuel consumption will double. In the next 10 years, the committee said, the number of vehicles registered will increase from 62,000,000 to 85,000,000.

Tax collections estimated by the committee indicate that gasoline consumption will be slightly under 1.1 billion barrels during the fiscal year which begins July 1. In the year ending June 30, 1972, it is forecast at 1.9 billion barrels.

Diesel-fuel consumption will increase at a still greater rate. In the coming fiscal year usage is placed at approximately 250 million barrels. By mid-1972 it will be close to 600 million barrels.

These figures represent only the taxed consumption. A new law just enacted this month lifts the tax on gasoline sold for use on farms for farming purposes through a refund system by which farmers will recover their tax payments annually.

The highway bill provides for similar refund of the increase—but not the present 2-cent tax—on gasoline sold for other nonhighway use. The increase in the tax on diesel fuel will not apply if it is used for a purpose other than highway motor use. And the increase also will not apply to special motor fuels used in motor boats or airplanes.

"The application of the additional motor-fuel taxes has been restricted to fuel used in highway vehicles (motor vehicles for the special motor-fuel tax) because the revenue under this bill is to be devoted to a highway program," the committee explained.

On that basis, the bill provides for refund of the additional 1-cent tax on motor fuels used in the operation of local or mass transportation systems. Limitations in the definition of such service are designed to restrict the exemption to local bus lines. This concession is necessary, the committee said, because many such systems already are operating near or below the break-even point. It is feared that the increased tax would have a serious effect on transportation essential to the large suburban population.

Producers Share Strike Loss

Texas commission prorates production drop due to Cities Service walkout; state's allowable for May also whacked

AUSTIN.—West Central Texas independents, some of them already hurting for markets for their oil, were reeling under another heavy blow last week.

The effects of a strike at Cities Service Oil Co.'s East Chicago, Ind., refinery and its subsequent shutdown have reached to the fields via a 40 per cent cut in Cities Service crude-oil purchases. This means a 25,000-bbl.-a-day cut in Texas.

Distressed producers appeared at the state-wide crude-oil allowable hearing here April 19 to ask for help.

One of the largest of the strike-affected fields is Round Top in Fisher County. Here Humble Pipeline gathers oil for itself and Cities Service. Humble is taking the full allowable from its well connections, but the Cities Service connections have been cut 40 per cent, according to Willis Jarrel, representing Round Top operator, W. H. Bryant.

The commission adopted one of Jarrel's suggested solutions to the crisis. It ordered the Round Top field allowable for May cut to 12 producing days from the state-wide 16 days after no takers volunteered for the distress oil. The order means that Round Top production will be distributed ratably. Each producer will cut back some whether selling to Cities Service or another buyer.

Operators in three other affected fields quickly requested similar action for them. The commission will consider these requests April 30.

The three fields are the South Leuders (King sand), South Leuders (Bluff Creek), and South Leuders (Cook Lime) fields—all in Jones County which adjoins Fisher County on the east.

Allowable cut . . . Getting down to routine business, the commission whacked 63,135 bbl. daily off the April 7 allowable while setting the initial figure for May at 3,289,240 bbl. daily.

The May figure, likewise, is 67,722 bbl. daily below the initial allowable for April.

The cut was attained by retaining 30-day April's 16-day schedule for May which has one more calendar day.

Purchasers' recommendations varied all over the lot. Five major buyers asked for 15 days, and five for 16 days. Phillips Petroleum Co. and Stanolind Oil Purchasing Co., both "very long" on crude, pressed for only 14 days, while Sun Oil Co. said it needed 17 days to supply its needs. Sun, however, recommended only 16.

MAY CRUDE-OIL ALLOWABLE

District—	May	Change from April 7
1—Southwest	71,349	— 594
2—Gulf Coast	155,257	— 4,789
3—Gulf Coast	476,798	— 3,823
4—Southwest	253,921	— 6,648
5—East Central	48,114	— 1,474
6—Outside E. Tex. field	130,799	— 3,449
6—E. Texas field	212,384	— 6,415
7-B—N. Cen. Texas	182,263	— 3,461
7-C—W. Cen. Texas	216,979	— 5,023
8—West Texas	1,116,556	—24,483
9—North Texas	303,315	— 3,354
10—Panhandle	121,505	+ 378
Total	3,289,135	63,135

Finding Reefs Is Easy

It takes experienced interpreters, but gravity surveys can readily locate Niagaran reefs in the Appalachians

COLUMBUS. — Finding oil-bearing reefs is one of the current exploration plays in this territory. These Niagaran reefs in the Appalachian area can be readily mapped with gravity surveys.

During the last several years over 40 reefs have been discovered in Indiana, Illinois, Michigan, and Ontario by drilling on gravity anomalies.

Richard A. Pohly, president of Pohly Exploration Co., Tulsa, told the Eastern A.P.I. production division meeting here April 25-27, that a density contrast exists between the reef and the surrounding rock; these contrasts enable the geophysicist to map the reef with considerable accuracy.

The gravity meter is normally considered a reconnaissance tool, but under certain conditions gravity surveys are highly successful in detailing oil traps. This method, Pohly stated, has largely been ignored in the Appalachians until recent years. Reefs in the northeastern

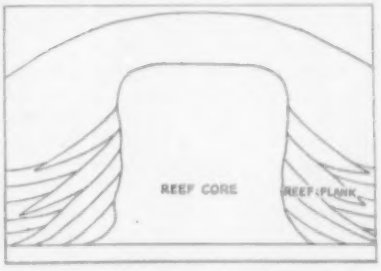


DIAGRAM of a typical Niagaran reef.

United States are stratigraphic traps rather than structures, and for this reason are difficult to map by normal subsurface methods. In Ohio, some new reefs have been uncovered simply by random drilling.

Because a reef mass has a greater density than the surrounding salt, shale, and limestones, the reef appears as a gravity maximum. The size of the eastern reefs varies from a few hundred feet in diameter to 2 or 3 miles, and the relief ranges from a few feet to several hundred. These reefs are prolific producers of oil and gas in Illinois, Indiana, Michigan, and Ontario.

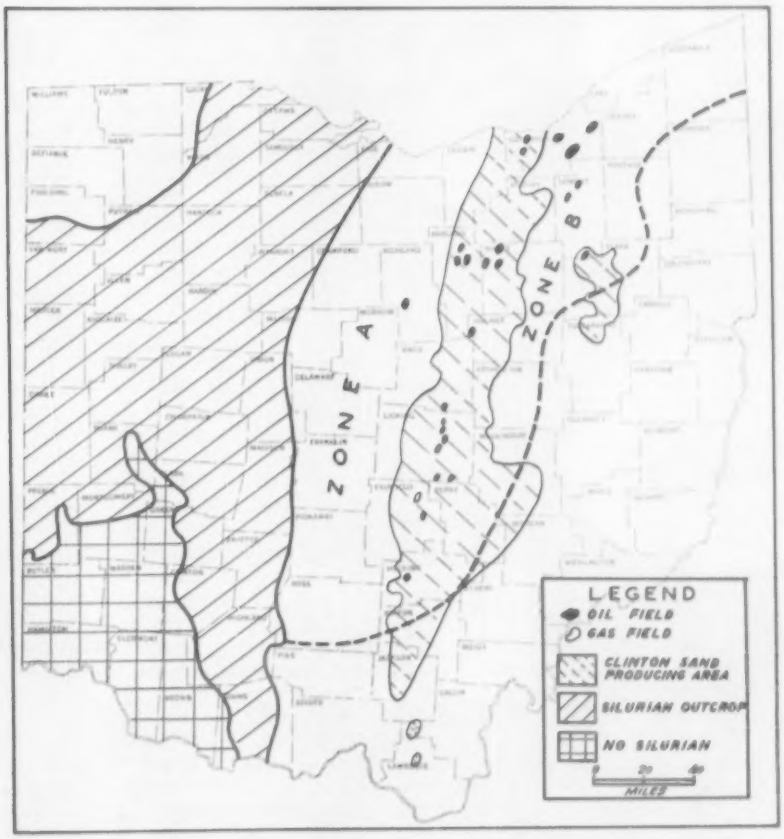
Very accurate gravity surveys are necessary to map the reefs, but a gravity crew can cover about one township a week. The final gravity map indicates quite reliably only the anomalies which, by size and intensity, could be produced by Niagaran reefs. Pohly emphasized, however, that only experienced gravity interpreters can successfully analyze the data and identify the reef anomaly.

Mapping strat traps . . . High-frequency seismic surveys should prove effective in mapping sand pinchouts and other types of stratigraphic traps that occur at fairly shallow drilling depths, R. J. Graebner, senior seismologist, Geophysical Service, Inc., Dallas, declared.

He outlined a series of experimental lines that were shot in Medina County, Ohio. The results of these experiments showed that seismic information can be obtained throughout the entire stratigraphic section of interest to oil geologists.

Careful coordination of the seismic data with known geologic conditions should enable the oil finder to map the more elusive stratigraphic trap, Graebner indicated.

High-frequency surveys have already been used successfully in Oklahoma and Texas to map the transition from sandstone to shale, he stated.



MAP OF OHIO showing zone most favorable for Niagaran reefs.

D-X to Modernize Plants

TULSA.—An $8-$10 million expansion project to upgrade its octane position will be undertaken by Sunray Mid-Continent Oil Co. at its Tulsa and Duncan refineries. The plants are operated by a subsidiary, D-X Sunray Oil Co.

Company directors approved the projects here last week. They include:

At Tulsa—a 12,000-bbl. daily catalytic reforming unit; a 12,000-bbl. daily hydrogenation unit augmented by a 2,500-bbl. daily alkylation plant; and a 1,500-bbl. daily butane-isomerization unit.

At Duncan—a 3,000-bbl. daily expansion of catalytic reforming equipment; an 8,000-bbl. daily pretreater to provide more charge stock to the catalytic cracking unit; and a 10,800-bbl. daily hydrogenation unit.

The projects will be completed by early fall of 1957. The company is now making premium gasoline of 96 and 97 octane and regular of 88-89 octane. Officials report the new projects were undertaken with a view to making 100-octane premium and 92-94 regular.

Crude Imports Gaining

First 6 months will see hike of 113,000 bbl. daily over last year; West Coast to take biggest share of increase

MOST of the gain in crude imports for the first half of this year will be on the West Coast.

The totals of refiners' reports to the Texas Railroad Commission indicate that crude imports for the first 6 months of this year will be almost 113,000 bbl. daily more than a year ago. Increased receipts on the West Coast will account for 88,500 bbl. daily of this gain, compared with an increase of 24,400 bbl. daily for the Gulf Coast and East Coast areas.

Refiners in the east brought in 18,500 bbl. daily less crude during the first quarter than in the corresponding quarter of last year. This decrease amounted to 2.8 per cent of crude imported in the first quarter of 1955.

West Coast crude imports gained 75,300 bbl. daily or 126.1 per cent in the first quarter. Part of the additional crude went to new refineries in Washington, but this new capacity in the Pacific Northwest did not account for all of the increase. Shell Oil Co. brought in 36,000 bbl. daily for its refinery at Anacortes, Washington.

All of this oil represented an increase over last year, since the refinery did not start operating until last summer. General Petroleum Corp.'s plant at Ferndale was operating last year, but the company's imports increased 6,100 bbl. daily this year with the refinery operating nearer capacity.

Imports by these two companies gained 42,100 bbl. daily, or 56 per cent of the total first-quarter increase on the West Coast. Shell reported a cutback to 4,000 bbl. daily for April. The company's Washington refinery was closed March 24 by strike.

Company reports show planned increases for Gulf Coast and East Coast areas in July and August. Last year, there was very little change in crude imports for these districts between the first and second quarters, or even during July and August. This year, company estimates of crude imports for July and August average 106,000 bbl. daily more than for the first quarter.

Product imports by companies reporting to the Texas Railroad Commission will change very little for the first half, with the decrease for the first quarter offset by increases in the second quarter. However, large percentage gains are forecast for July and August.

What the Companies Told the Railroad Commission

(Thousands of barrels daily)

	Actual*		Forecast*				
	Mar. 1955	Mar. 1956	Apr. 1956	May 1956	June 1956	July 1956	Aug. 1956
CRUDE—EAST COAST:							
Atlantic Refining Co.	67.8	61.2	67.5	67.5	67.5	67.5	67.5
Cities Service Co.	42.4	23.4	24.3	35.8	32.5	32.9	41.0
Eastern States Petroleum Co.	9.1	18.9	14.0	15.0	22.5	22.5	22.5
Gulf Oil Corp.	132.0	149.0	120.0	150.0	150.0	140.0	140.0
McBride Oil & Gas Corp.	3.2						
Phillips Petroleum Co.	6.4	17.9	12.0	11.6	12.0	11.6	11.6
Sinclair Oil Corp.	65.7	84.0	67.8	70.3	73.4	73.4	73.4
Shell Oil Co.		0.8	1.0	1.0	1.0	1.0	1.0
Socony Mobil Oil Co., Inc.	80.1	63.8	72.6	66.5	66.5	66.5	66.5
Sohio Petroleum Co.		1.7	2.0	1.9	2.0	1.9	1.9
Southwestern Oil & Ref. Co.	7.3		3.8	3.7	3.8	(¶)	(¶)
Standard Oil Co. of Calif.	64.2	67.0	81.1	81.1	81.1	81.1	81.1
Standard Oil Co. (Ind.)	9.9	10.2	13.2	16.3	16.9	20.1	20.4
Standard Oil Co. (N. J.)†	87.0	75.0	79.0	79.0	79.0	79.0	79.0
Sun Oil Co.	13.3	30.8	23.0	35.0	57.5	61.3	57.3
The Texas Co.	66.5	67.2	52.1	72.9	79.7	75.9	79.5
Tide Water Assoc. Oil Co.	11.0	18.3	14.5	13.9	15.0	13.3	15.1
Total East Coast	665.9	689.2	647.9	721.5	760.4	751.7	761.5
CRUDE—WEST COAST:							
Shell Oil Co.		39.5	4.0	50.0	37.0	18.7	18.1
Socony Mobil Oil Co., Inc.	27.5	35.4	32.7	37.5	42.5	39.5	39.5
Standard Oil Co. of Calif.	8.9	9.0	21.6	21.6	21.6	21.6	21.6
The Texas Co.	11.8	6.6	45.5	32.1	35.3	25.4	24.5
Tide Water Assoc. Oil Co.	7.3	58.8	37.0	66.2	32.2	52.4	60.5
Total West Coast	55.5	149.3	140.8	207.4	168.6	157.6	164.2
Total crude	721.4	838.5	788.7	928.9	929.0	909.3	925.7
PRODUCTS:							
Asiatic Petroleum Co.	11.5	3.8	3.8	4.6	4.5	7.5	7.8
Eastern States Pet. Co.	25.0	12.4	10.0	10.0	10.0	10.0	10.0
Gulf Oil Corp.	4.0		3.0	7.0	7.0	7.0	7.0
Shell Caribbean Pet. Co.‡	151.0	115.0	169.0	94.0	92.0	87.0	94.0
Shell Oil Co.	24.4	20.2	21.5	22.4	24.6	22.9	22.4
Sinclair Oil Corp.		4.2					
Socony Mobil Oil Co., Inc.	4.1	10.0	8.1	8.1	8.1	8.1	8.1
Standard Oil Co. of Calif.			2.5	2.5	2.5	2.5	2.5
Standard Oil Co. (Ind.)§	15.8	21.6	39.3	22.6	17.0	19.4	20.9
Standard Oil Co. (N. J.)†**	216.0	146.0	124.0	124.0	124.0	118.0	118.0
The Texas Co.††					4.2		4.0
Total products	451.8	357.2	427.2	341.2	339.9	328.4	340.7
Total crude and products	1,173.2	1,195.7	1,215.9	1,270.1	1,268.9	1,237.7	1,266.4
Bonded fuel included**	79.9	67.5	84.6	92.4	92.6	92.9	92.7

*From company reports to the Texas Railroad Commission. †Based on quarterly estimates. ‡Imported by independent distributors. §Received through suppliers who can furnish either domestic or foreign oil. ¶Unreported by company but an average of 3,700 bbl. daily included in totals. ‖Mostly duty free for bunkering ships in foreign trade. **Includes bonded drawback for foreign flag international bunkers as follows: March, 24,000 bbl. daily; second and third quarters, 46,000 bbl. daily. ††To be imported on the West Coast.

CRUDE IMPORTS*

(Thousands of barrels daily)

	1955	1956	Per cent change
January	716.8	730.5	1.9
February	747.3	785.2	5.1
March	721.4	838.5	16.2
First quarter	727.9	784.7	7.8
April	669.4	788.7	17.8
May	721.7	928.9	28.7
June	779.6	929.0	19.2
Second quarter	723.5	882.7	22.0
July	762.5	909.3	19.3
August	748.2	925.7	23.7

PRODUCT IMPORTS*

(Thousands of barrels daily)

	1955	1956	Per cent change
January	508.1	483.4	— 4.9
February	519.0	476.3	— 8.2
March	451.8	357.2	—20.9
First quarter	492.0	438.1	—11.0
April	356.9	427.2	19.7
May	327.1	341.2	4.3
June	306.7	339.9	10.8
Second quarter	330.2	369.1	11.8
July	253.6	328.4	29.5
August	263.7	340.7	29.2

*From reports to the Texas Railroad Commission.

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Allowable Rule Changed

Texas to permit discovery allowance only for new-pool openers in future; 1-mile stepouts won't receive bonus

DALLAS.—The Texas Railroad Commission is tightening up its policy on discovery allowables. The result: There will be no more special allowables for new producing wells solely because they were drilled a mile or more away from the nearest existing well.

Commission Chairman William J. Murray announced the policy change at the recent state-wide crude-oil allowable hearing. He said in the future an operator must show by geological and engineering data that his well is in fact a new-pool opener.

Texas regulations grant such a well initially a much higher allowable than is permitted a development well. The higher allowable lasts for 1½ years or until completion of the sixth well in the new field—whichever comes first.

Texas oil operators for the most part expect little if any change in the state drilling picture to result from the action. They give these reasons:

...There are few fields being discovered or already existing these days where an operator could step out a mile and still be in the same field. There reportedly have been a few cases in the past where an operator stepped out a mile and received a discovery allowable knowing that the new well was only an extension.

...The gamble is too high. Instances are even fewer where an operator would be willing to gamble on stepping out a mile just to get the higher allowable.

...The payoff is too low. Maximum benefit of the discovery allowable is seldom realized anyway. Most long stepouts are the result of farm-out agreements. If the stepout is completed successfully, offset operators are quick to drill to participate in the discovery allowable. Thus the limiting sixth well is soon completed.

The full discovery-allowable benefit is usually enjoyed only when the operator has assembled a large acreage block.

...Move anticipated. Most operators, especially the larger ones, already are sending in data with their discovery-allowable applications to prove the well is in a new pool.

The minority view . . . A few operators, on the other hand, feel that the ruling will have some effects. They think that:

...It will be tough in some cases, especially in drilling around old salt domes, to prove that a new well is in a separate pool when only one well has been drilled.

...There may be fewer wells drilled over-all. This is because the rule will cause some decrease in allowables, thus cutting into cash available for more drilling. The smaller operators of course would be affected most in this respect.

...Few long stepouts will be drilled. Emphasis may be on development closer in or on "true wildcats."

A discovery bonus . . . The discovery allowable actually is a bonus intended to act as an incentive to a wildcatter in that it permits him to recoup somewhat for the greater drilling risk.

Discovery allowables are granted on a depth scale similar to the yardstick depth allowables usually given a development well. The two scales don't differ drastically figurewise. But the discovery allowable finds its merit in that the operator can produce this barrelage every day, whereas the development well is permitted to produce the yardstick figure only on the number of producing days fixed each month by the Texas Railroad Commission according to market demand. This makes a big difference.

For instance, the discovery allowable for a wildcat completed between 3,000 and 4,000 ft. is 80 bbl. a day. The operator can produce this figure 30.4 days a month (the number of days in the average month). At the end of the 18-month discovery allowable period (if it went that far), he could have produced 43,776 bbl. of oil.

The yardstick allowable for a development well completed at the same depth is 64 bbl. a day if on a 20-acre proration unit. This month and next month Texas will adhere to a schedule of 16 producing days. Supposing the 16-day schedule is the average for the year, the equivalent development well could produce only 16,632 bbl. during an 18-month period—just a little over a third permitted the wildcat.

If completed on 40-acre spacing, the development well would have less disadvantage, being permitted 24,182 bbl. of allowable during the 18-month period (84 bbl. per producing day).

The per well benefit could be compounded if this hypothetical wildcatter controlled considerable acreage in the vicinity of the well and followed up quickly with four more completions.

Conversion Delayed

● Court ruling holds up Little Big Inch switch to products duty for a year

SHREVEPORT.—Texas Eastern Transmission Corp.'s planned conversion of the Little Big Inch pipeline from natural gas to products service has been set back at least a year, according to George Naff, company president.

Until March 8 of this year, Texas Eastern had the conversion time table geared so that products would begin moving through the 20-in. line by June 8.

Last week, Naff told stockholders in a report on first-quarter company operations that the adverse March 8 decision of the U. S. Court of Appeals for the District of Columbia meant Texas Eastern could not finish the conversion job before July 1, 1957.

The Appeals Court upheld a contention by two Mississippi barging firms, Chotin Towing Co. and Greenville Towing Co., that the Federal Power Commission in the Texas Eastern case erred in refusing to accept evidence on points raised by the barge operators.

The FPC at that time ruled only on the feasibility of retiring the Little Big Inch from gas service and the construction of new gas facilities to take over the lost capacity.

On direction of the court, the FPC has reopened hearings on the matter and will consider such factors as the effects the conversion would have on:

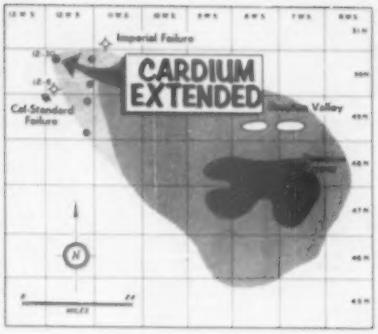
...Competing Products Carriers. This will involve looking into the possibilities of any antitrust violations.

...Costs to gas consumers. Barge operators argued Texas Eastern should not be permitted to absorb losses from products operations out of revenues from gas—that this would hike the consumer costs.

...The national defense. Barge firms contended the proposed products carrier would drain off Mississippi-Ohio River traffic and cut transport facilities available in case of emergency.

The conversion plan contemplates using 1,168 miles of the 1,479-mile line for carrying products. The products section, from Beaumont to Moundsville, W. Va., would carry a complete range of products, including L.P.G.

Meanwhile, a new 30-in. line built from Beaumont to Kosciusko plus a large expansion of compressor horsepower on the previously existing 30-in. from Kosciusko on the Connellsville, Pa., have been completed to take over the Little Big Inch gas load.



Pembina Pinched

● Cal-Standard wildcat extends Cardium, another limits southwest flank

EDMONTON. — The Cardium pay trend of Alberta's Greater Pembina region apparently is moving northwest, but is squeezed on the northeast and southwest flanks by two failures.

Reports from California Standard Co. wildcats last week gave a clearer picture of the Pembina-Cardium pay trend. One Cal-Standard wildcat proved a 5-mile northwest extension of the trend. The other was a failure on the southwest flank.

Both tests are in a four-township reservation for which the company paid $10,500,002 last June at an Alberta crown lease sale *(The Oil and Gas Journal, June 27, page 70).*

The Cal-Standard discovery is the 12-30 Northeast Cynthia on L.S.D. 12, 30-50-12w5. It extended the indicated limits of the Cardium sand pay 5 miles to the northwest and added half a township to the proven area on the Cynthia block. The eastern half of the block was proven previously by four Cal-Standard producers.

Depressing news came in Cal-Standard's reported failure at 12-6 Northeast Cynthia. The dry hole is 5 miles south on L.S.D. 12, 6-50-12w5. It is in the center of the company's expensive Cynthia parcel, and poses a big question for the future of the western half of the reservation.

Rubber Plant Hard to Sell

WASHINGTON.—Competition for the last fragments of the Government's once-large synthetic-rubber industry is not very keen.

The rubber-disposal commission, ordered by Congress to make a last effort to sell the alcohol-butadiene plant at Louisville and catalyst manufacturing equipment in Baltimore, or lease them for a long period, has received only two offers for each.

Publicker Industries, Inc., which holds a 3-year lease on the Louisville plant, now in partial production, made an offer for both.

Union Carbide & Carbon Corp. made the only other offer for the butadiene plant. Davison Chemical Co., division of W. R. Grace & Co., was competing bidder for the catalyst equipment.

Phillips Develops Rubbers

BARTLESVILLE, Okla.—Four new synthetic-rubber materials, one of which may rival natural and the other excel it, have been developed by scientists of Phillips Petroleum Co.

Officials report researchers are producing in the laboratory a synthetic with the structure and properties of natural rubber. Another butadiene-base material has been developed which may excel natural. It runs 20 degrees cooler than styrene-type synthetic and is 10-15 per cent more resilient than regular GR-S synthetic. It performs better at low temperatures.

A second butadiene-base synthetic is a high-softening point resin which has potential uses in plastics and rubber fields. Phillips' scientists also are making from isoprene a synthetic counterpart of natural gutta percha or balata. It is used where toughness is important such as for insulation, belting, and golf balls.

Strike Clouds Nominations

CALGARY.—The strike at Shell Oil Co.'s Anacortes, Wash., refinery may have a heavy impact on Alberta crude-oil allowables for May.

Purchasers have asked the Alberta Petroleum and Natural Gas Conservation Board for 365,164 bbl. daily. Of this figure, 40,000 bbl. daily hinges on the Anacortes plant's going back on stream.

U. S. refineries are slated for 113,915 bbl. daily, including the 40,000 bbl. for Anacortes. The Interprovincial pipeline to the east will carry 182,155 bbl. daily and Trans-Mountain will carry 125,935 bbl. daily, with 66,725 bbl. going to the U. S. Pacific Northwest.

Deliveries for U. S. refineries include General Petroleum Corp., Ferndale, Wash., 26,500 bbl. daily; British American Oil Co., Ltd., Superior, Wis., 15,150; International Refineries, Inc., Wrenshall, Minn., 9,680; Great Northern Oil Co., Pine Bend, Minn., 8,200; Lake Superior Refining Co., Superior, Wis., 5,160; Northwestern Refining Co., St. Paul Park, Minn., 5,000; Bay Refining Corp., Bay City, Mich., 4,000; and Union Oil Co., Cut Bank, Mont., 225.

Industry BRIEFS

DENVER.—Frontier Refining Co. has purchased the 160-acre Horseshoe-Phebus lease in Hamilton Dome field of Hot Springs County, Wyoming, from John Oil Co., Houston. Production from 10 wells is about 500 bbl. a day. An eleventh well is being completed and another is drilling. Gross reserves in the Chugwater, Phosphoria (Embar), and Tensleep formations are estimated at 3,500,000 bbl.

AUSTIN.—The Texas Railroad Commission has ordered all operators of wells in East Texas field to file detailed well-status reports by July 1. Failure to comply with the order will be cause for severance of pipeline connections, the commission said.

AUSTIN.—Ector County in West Texas outproduced all others with 51,425,469 bbl. during the fiscal year ended August 31, 1955, according to final figures just released. Gregg County, the 1954 leader in the middle of East Texas field, declined more than 3,000,000 bbl. to third place with 48,032,646. Andrews County, just north of Ector, produced 50,717,052 to rank second. Total Texas production rose to 997,569,256 bbl. compared with 967,240,871 bbl. the previous year.

AUSTIN.—Miami Operating Co. has the green light from the Texas Railroad Commission to waterflood 1,005 acres in KMA field of Wichita County, North Texas. The company estimates it will recover an added 1,850,000 bbl. of oil from the 3,900-ft. KMA horizon.

The commission, meanwhile, is considering a request for another flood which would add another 2,160,000 bbl. of oil from the Yates sand of Emperor field, Winkler County, West Texas. The application was filed by M. E. Daniel and Lester Clark, Breckenridge, Tex., independents.

TULSA.—Sinclair Research Laboratories, Inc., is more than doubling the size of its production-research building here. The extension, scheduled for completion in July, will add 8,600 sq. ft. of floor space and boost total laboratory space to 16,000 sq. ft. Work is under way.

CASPER, Wyo. — Bonus payments totaling $376,829 were bid on 6,586 acres of land by Stanolind Oil & Gas Co. at a sale of oil and gas leases on 45 tracts in Wyoming's Wind River Indian Reservation. The high bid was $168,082, or $208.28 per acre, for 807 acres in the North Sage Creek field area.

Oil Future Uncertain

Austrian elections next month may determine what happens to Europe's biggest field, claims of western companies

THE May election in Austria may settle the future of the nation's oil industry, including Western Europe's biggest oil field.

The industry's future, especially regarding western oil companies whose former leases are now the source of most production, has been obscure since Austria obtained control of operations from Russia last August.

If the conservatives win a clear-cut victory, they say they will settle claims of western companies on properties expropriated by the Germans in 1938, under the terms of a government memorandum issued late last year.

The memorandum did not propose the return of concessions to the original owners, but it did call for an operating agreement for development of equivalent production in the case of Rohoel-Gewinnungs A. G. (R.A.G.), jointly owned by Socony Mobil Oil Co., Inc., and Royal Dutch-Shell *(The Oil and Gas Journal, January 2, page 69)*.

On the other hand, a victory for Austria's Socialistic Party might mean that future exploration and production would be handled solely by a state monopoly.

If neither the conservatives nor socialists are strong enough to form a cabinet of their own, political leaders will again face the task of finding a compromise on the oil question.

Big field involved . . . The best prize of all is Matzen-Auersthal field. It lies about 20 miles northeast of Vienna, half way between Zisterdorf and the Danube River.

The field is on a lease formerly held by R.A.G. Last year it produced about 54,700 bbl. daily, or 78.4 per cent of the total Austrian output. Smaller fields in the area are in a state of decline, making Matzen-Auersthal even more important to Austria.

The field got its double name from two local uplifts of the single east-west structure. The western portion has a proven area of about 8 by 5 miles.

The most important producing zone is the Sixteenth Tortonian. It has an average thickness of 100 ft. and ranges from 5,200 to 5,500 ft. in depth. About 180 of the 320 wells in the field produce from this zone and account for 65 to 70 per cent of the output.

About 90 per cent of these wells are flowing. They have an average output of 210 bbl. daily of 24.5°-gravity asphaltic crude.

Other Tortonian zones, chiefly the eighth and ninth, produce about 9,000 bbl. daily of 23° to 24°-gravity oil from 130 wells. About half are flowing.

The Helvetian zone underlies the Tortonian at depths from 5,600 to 7,500 ft. The crude varies from 38° to 41° gravity, including some condensate, and has a paraffinic base. Ten Helvetian wells are now on production. Helvetian is not yet fully defined, and exploration work is being extended north.

The field has a powerful water drive from the south. The edge-water limit is well known and its encroachment is controlled. The Sixteenth Tortonian has a gas cap which is also controlled.

Secondary-recovery methods have been considered. But a Russian production engineer expressed the opinion that no water flooding would be necessary.

Two natural-gas zones are productive at Matzen. They are in the Sarmatian at 2,600 to 3,000 ft. Last year, output averaged 22,000 M.c.f. daily, or 29.8 per cent of the total Austrian output. The gas is shipped to Vienna by a 20-mile, 20-in. pipeline.

The Soviet Petroleum Administration developed Matzen-Auersthal systematically after its discovery in March 1949. At first, some wells were overproduced, but Austrians say that in general the field was developed efficiently.

At present, Austrian engineers are trying to operate the field even more efficiently by trying to adapt the output of individual wells to energy conditions.

Aderklaa past peak . . . Aderklaa field, southwest of Matzen-Auersthal near Vienna, another field developed by the Russians on the basis of R.A.G. preliminary work is declining. Output last year averaged 3,800 bbl. daily of crude and 2,900 M.c.f. daily of natural gas.

The 35-well field produces 39° to 46.5° paraffinic crude, including some condensate, from the fifth Tortonian at a depth of 5,600 to 5,900 ft.

The Austrian Petroleum Administration has 32 rigs available at present, including two Russian turbo drills. Six of the rigs are being used for exploratory drilling near Aderklaa, Kagran, Wittau, Radensburg, and Goettlesbrunn.

Cuban Gasser Lost

Cuban American will drill offset aimed at same pay

CUBAN American Drilling & Exploration Co. of Dallas has temporarily abandoned its 1 Cristales wildcat in Cuba which last month appeared headed for completion as the island's first commercial gas well.

Initial flow was estimated at 5,000,000 cu. ft. daily from 2,708 to 2,738 ft. Efforts to increase pressure and flow by more perforating resulted in recovery of water.

Cuban American officials believe the water is coming from a section other than the gas pay due to a faulty cement job. An offset, the 1A Cristales, is planned within a thousand feet of the original test as soon as another rig can be brought in.

Other wildcats . . . The Dixie Drilling Co. rig which sank the 1 Cristales has been moved to another wildcat location and is drilling below 3,400 ft. at the 1 Guayos. It's located 4½ miles west of the 1 Cristales and about midway between that test and Jatibonico field, the only oil pool of consequence in Cuba, in Camaguey Province.

A third wildcat, the 1 Vega Grande, about 6 miles northeast of Sancti Spiritus and 30 to 35 miles west and south of 1 Cristales, is drilling below 6,000 ft.

Cuban American also has staked three more locations. These will be drilled as soon as rigs are freed from the Guayos and Vega Grande holes. The 1 Cristales was the second Cuban venture by the company, which with associates holds more than a million acres in concessions in Cuba's central basin.

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Canada Southern Pet.
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Peru's Amazon Basin Gets First Pipeline

THE first pipeline in the Amazon basin of Peru has gone into operation.

The 46-mile, 4-in. line is an outlet for Ganso Azul Cia. de Petroleo's Agua Caliente field, the only Peruvian production east of the Andes Mountains. The line leads to Pucallpa, a port on the Ucayali River. It was built at a cost of $460,000.

Ganso Azul (Blue Goose) is owned 80 per cent by Texas Gulf Producing Co. and 10 per cent each by Kendall Refining Co., Bradford, Pa., and Bay Refining Corp. The company expects to expand present output of about 2,000 bbl. daily from 16 wells to 2,500 to 3,000 bbl. daily.

The 5,000 bbl. daily line was laid through jungle until it emerged at the Trans-Andean Highway about 20 miles south of Pucallpa. It parallels the highway the rest of the way.

From the Pucallpa terminal, crude will be barged to the Peruvian Government's 2,500-bbl. daily refinery at Iquitos, about 600 miles downstream. Crude also will be barged 1,800 miles down the Ucayali and Amazon rivers to the new 5,000 bbl. daily refinery at Manaus, Brazil. At first, shipments are expected to average about 500 bbl. daily for Iquitos, and 1,000 to 1,500 bbl. daily for Manaus.

Construction of the line took about a year. Subsidiary equipment included two 30,000-bbl. tanks at Pucallpa. Besides reducing transportation costs, the line will avoid delays during the dry season when barges are unable to navigate from Aguas Calientes to Pucallpa on the Pachitea River *(The Oil and Gas Journal, October 31, 1955, page 68).*

RIGHT-OF-WAY for the crude line from Ganso Azul production to the Ucayali River snakes through the dense Peruvian jungle.

French Get Prize Libyan Block

THE Libyan Government has filled the last lease gap along the Algerian border by granting an exploration concession to Cie. Francaise des Petroles.

Several companies, including a Royal Dutch-Shell subsidiary, have jumped for the spot after a wildcat discovery across the Algerian frontier to the southwest.

The C.F.P. concession covers about 3,750 sq. miles in Fezzan. It borders the Algerian frontier for about 17½ miles, filling an open space between Conorada's concessions to the north and acreage to the south held by Esso Standard of Libya, Inc.

The race for the open section of frontier began in February after a promising well was drilled by Royal Dutch-Shell and the French. The test was located less than 3 km. from the Libyan boundary, across from the concession held by the Standard Oil Co. (N.J.) subsidiary. Unofficial reports indicated the well tested 300 bbl. daily from shallow horizons *(The Oil and Gas Journal, February 13, page 95).*

The French Government and the well owners, Cie. de Recherches et d'Exploration de Petrole au Sahara (C.R.E.P.S.), have been tight-lipped about the test. The well is located in a remote, desert region where there is some question about the exact boundary *(The Oil and Gas Journal, March 19, page 136).*

Thirteen companies had previously obtained exploration concessions over more than 91,000,000 acres in Libya. The grants were cleared by the government after overlapping applications were ironed out in talks which began last October *(The Oil and Gas Journal, January 16, page 87).*

Ironically, there was no competition for Fezzan acreage when original applications were made. Conorada, Jersey Standard, and Libyan American Oil Co. (Texas Gulf Producing Co.) were the only companies which applied for concessions in the province. Libyan American's concession borders the frontier to the south of Jersey Standard's acreage.

Gas Field Opened

West Pakistan's new Uch pool may rival Sui output

A second gas field, nearly as big as Sui, has been proved at Uch in the Bugti-Marri territory of Baluchistan in West Pakistan.

Pakistan Petroleum, Ltd., controlled by Burmah Oil Co., Ltd., spudded in the Uch well about 43 miles east of the Sui gas field in February 1955. The well encountered high-pressure gas zones between 4,000 ft. and 6,000 ft., but was drilled to 11,000 ft. in search of an oil formation. No oil shows were found.

The well was plugged back to test the gas shows last October and since that time extensive tests have been carried on. Reports from Karachi last week indicated the test has found another major gas reserve. The gas is described as of lower calorific value than Sui gas and "more contaminated with impurities."

The Uch anticline is the third tested so far in Baluchistan by Pakistan Petroleum.

The second structure tested was at Zin, about 22 miles north and slightly west of Uch. A well at Zin was abandoned after it found no oil shows and only low-pressure gas regarded as noncommercial.

Mexican Line Complete

Pemex will start up its new 304-mile, 12-in. Tampico - Monterrey products pipeline in May. Initial capacity will be 20,000 bbl. daily, but throughput can be boosted to 50,000 bbl. daily.

The project will make Monterrey a distribution center for northern Mexico. The three refineries in the Tampico area, Madero, Mata Redonda, and Arbol Grande, have a total capacity of about 150,000 bbl. daily. Their combined output last year was around 99,000 bbl. daily.

French Refinery to Expand

Societe Francaise des Petroles BP, the French associate of British Petroleum Co., Ltd., will add another 18,000 bbl. daily to the capacity of its Lavera refinery near Marseilles.

Heavily damaged during World War II, the plant's capacity has been increased from time to time since the war to its current 50,000-bbl. per stream day. The new unit will replace a portion of the old distillation capacity of the plant and raise its over-all per stream day capacity to about 68,000 bbl.

Brazil Lets Contracts

Government's Mataripe refinery to be expanded

THE Brazilian Government's oil corporation, Petrobras, has awarded an engineering and design contract to M. W. Kellogg Co. for the expansion of Mataripe refinery to 37,000 bbl. daily.

The project is the first step by President Juscelino Kubitschek's new government in its program to expand Brazil's refining capacity to 200,000 bbl. daily within 5 years.

The expansion plan also is a continuation of the former government's oil policy of making Brazil self-sufficient for most refinery products. Since early 1954, total refining capacity has risen from 7,000 bbl. daily to 120,000 bbl. daily.

Mataripe, located near Brazil's only producing area in the state of Bahia, has a capacity of 5,000 bbl. daily. Kellogg built a 2,500-bbl. daily thermal combination refinery in 1950 and duplicated the installation in 1953.

The new plant will be designed to handle all types of domestic crude, including Candeis, Itaparica, Don Joao, Mata, and Catu. Facilities will include one of the world's largest wax plants, rated at 60 tons per day, and the country's first lube-oil plant, with a capacity of 3,000 bbl. daily.

Existing thermal cracking units will be converted to other operations.

Along with crude distillation facilities, new processing units will be added for vacuum distillation of lube-oil fractions, vacuum flashing of catalytic cracker feed, catalytic cracking with an Orthoflow fluid catalytic cracker of latest design, catalytic polymerization, propane de-asphalting, phenol treating, wax finishing, filter aid manufacturing, and wax packaging.

Materials and equipment for the project will be procured in Europe with "soft" currency, and also in Brazil. Petrobras has contracted with a French consortium for materials under a long term financial agreement.

Kellogg will set up a training program for the refinery's operating staff, and will help develop Brazil's own refining training program.

Chile Drafting Oil Law

The Chilean Government is drafting legislation which would open the country to foreign oil companies.

Strong resistance is expected in congress. Chile, like Argentina and Brazil, has refused to grant concessions to foreign oil firms. But President Carlos Ibanez' conservative government has been able to enact a law with terms more favorable to foreign copper companies.

Crude production under the state-owned National Petroleum Co. is around 8,800 bbl. daily in Tierra del Fuego.

Permit Extended

But Esso-Rep gives up half of Parentis field acreage

ESSO-REP, operator of Parentis field in southwestern France, has given up half its exploration acreage in the area and obtained a 5-year extension on the remaining half.

The acreage was turned back to the government at the expiration of a 5-year permit to comply with French law. The remaining 50 per cent comprises nearly 2,200,000 acres in 3 sections. The new termination date is February 20, 1961.

Parentis field was discovered and developed under the original permit issued in 1951. The field is the biggest in France with an output of nearly 20,000 bbl. daily. It is now producing under a special government decree. An exploitation permit covering 23,000 acres has been applied for, but has not yet been granted.

The initial permit was issued to Esso Standard S.A.E., but Esso-Rep, formed to handle exploration and production operations, now holds title to the acreage. Esso-Rep is owned 89 per cent by French Esso Standard, in turn owned 63.2 per cent by Standard Oil Co. (N. J.) and 18.35 per cent by Gulf Oil Corp.

In northeastern France, another area of exploration interest, the government has issued two exploration concessions totaling nearly 2,300,000 acres to Cie. Francaise des Petroles.

Record Tankers Planned

Authorization to build two record-breaking 87,200-ton oil-ore tankers in a former Japanese naval yard has been asked by National Bulk Carriers, Inc., of New York City. One would be started next March and the other the following August.

National earlier gained permission to use the same yard for construction of two similar tankers rated in excess of 80,000 tons. Work is already under way on one.

The latest tankers would have bigger displacement than any ship afloat, eclipsing the world's largest liner, the Queen Elizabeth, by 3,300 tons.

They will be built by Kure Shipyards, Inc., which is operated by National Bulk Carriers.

International BRIEFS

The Norwegian Government and A/S Norske Esso, owned 56 per cent by Standard Oil Co. (N. J.), have completed preliminary arrangements for a refinery to be built at Skjebergkilen, about 50 miles south of Oslo. The $30,000,000 plant would supply products to Norway, Denmark, and Sweden. Because of government investment restrictions, work could not begin until 1958. The company now operates Norway's only refinery, a 1,800-bbl. daily plant at Vallo.

An Austrian equipment manufacturer will begin marketing turbo-drilling outfits later this year. The firm, Mannesmann-Traunzl A.G., of Vienna-Strebersdorf, will sell a modified version of a recent Russian model on which it has taken out patents.

Denmark is negotiating a 3-year contract to buy oil products from Russia. Imports will total about 900,000 bbl. the first year and 1,800,000 bbl. the second and third years.

A new gas-injection record was set at Abqaiq field in Saudi Arabia in February when 170,400,000 cu. ft. daily was recycled, a 6.7 per cent increase over the January level. The compressor plant was designed for an average capacity of 150,000,000 cu. ft. daily. Abqaiq is Saudi Arabia's second biggest crude producer, averaging more than 280,000 bbl. daily.

A new tanker mooring 3 miles off Lutong refinery in British Borneo will enable big tankers to load there for the first time. The World Concord will be the first supertanker to use the mooring. It will take on more than 230,000 bbl. of crude from Seria and Miri fields this month and head for Shell's refinery at Pernis, Netherlands.

Pacific Western Oil Corp., holder of the concession on Saudi Arabia's one-half interest in the Kuwait-Saudi Arabia neutral zone, has been changed to Getty Oil Co. J. Paul Getty, California financier and oil man is president.

The company shares production from about 30 wells in Wafra field with American Independent Oil Co., which holds the concession on Kuwait's interest in the zone.

The first 1,500 bbl. of gasoline produced at the new refinery at Batman in southeastern Turkey were marketed in Iskenderun this month. The 7,000-bbl. daily plant uses crude from the nearby Raman field.

finding Oil in '56

SPECIAL EXPLORATION SECTION ANSWERING . . .

- **What is the geological outlook?**
- **What is the geophysical outlook?**
- **Where are the world's major oil fields found?**
- **How does geophysics map new oil and gas fields?**
- **Where are the future U. S. oil provinces?**

Geologists' Outlook Hinges on Answers to Three $64 Questions . . .

1. What will the demand be?

2. Is there enough petroleum to supply it?

3. Can we find it?

by A. I. Levorsen

A SPECIALIST in any one of the earth sciences, as petroleum geology, geophysics, geotectonics, geochemistry, or stratigraphy, is in fact, a geologist, for geology is by definition **earth science** from the Greek, **ge,** earth and **logy,** science. There is no outlook in the geology of petroleum that does not include geophysics; neither is there much of any future for geophysics in petroleum that does not include geology. Whether specialized or not, we are all geologists. We are in the same boat together and we are subject to the same winds of fortune.

The way I would like to examine the outlook for geology in petroleum—and that means the outlook for both petroleum geologists and geophysicists—is to break it down into three questions. These are:

1. What will be the petroleum demand?
2. Is there enough petroleum to supply it?
3. Can we find it?

What Will Be the Petroleum Demand?

It is impossible these days to consider the future demand for petroleum energy without considering the peacetime impact of atomic energy on this demand. My reading of the predictions leads me to the conclusion that the over-all effect of atomic energy on the petroleum industry will be negligible for the foreseeable future—certainly for the next 20-30 years.

This, then, puts the chief responsibility for an expanding supply of energy right back where it was before the atomic age—in the lap of the petroleum industry. If we project ahead the production and demand curves of the past, we see a minimum demand coming up of twice our present consumption in the next 20-30 years. And it may double in even less time than this if the more optimistic projectors are right. As a minimum requirement, we must find well over 100 billion barrels of recoverable oil between now and 1980. But we may also be called upon to find this oil even sooner.

A real job ahead . . . The petroleum geologists, geophysicists, and engineers, and all those in the oil industry concerned with petroleum exploration and supply, have a real job ahead. If peace were to prevail in the world, the obvious solution would be to import our needs, chiefly from the Middle East. But this is dangerous.

There are several alternatives, however. One is to find enough oil in the Western Hemisphere, but this also has an element of danger because waterborne oil, even from South America,

	TECH.	RESOURCES	BIL. BBLS.	RESERVES
1	E	Recoverable petroleum	30 - 40	Available now
2	G G	Undiscovered oil-gas	100+ ? +	Present and/or improved technology & economics
3	R E	"Non" recoverable oil	180±	Improved technology and economics
4	R E	Tar and asphalt deposits	300 - 500	Improved technology and economics
5	R E	"Oil" or kerogen shales Coal	100+ +	Improved technology and economics

E = Engineers G = Geologists - Geophysicists R = Research teams

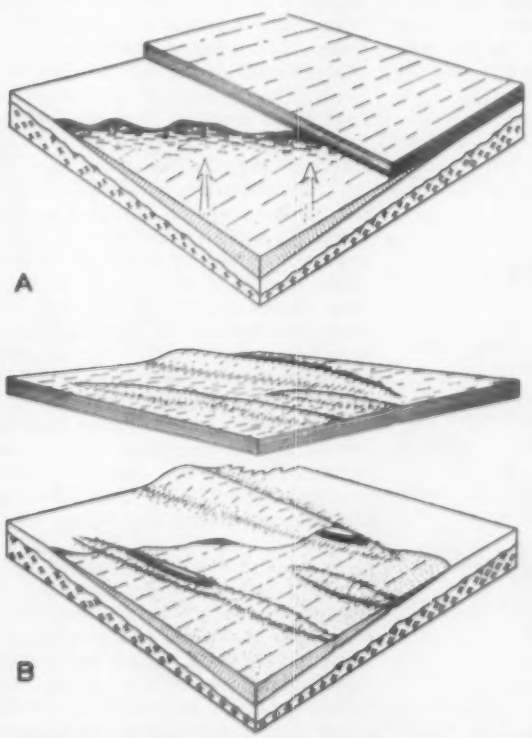
TECHNOLOGY converts oil resources into oil reserves. The roles of the various technical men in developing these resources are shown in the column marked "Tech." Fig. 1.

is vulnerable. Another, to find oil in North America where most of the transportation is inland, is almost as good as finding it within the United States, which has been the conventional method.

Is There Enough Petroleum to Supply the Demand?

We find, when looking at our future supply, that it may be broken down into two categories—reserves and resources. Reserves are supplies of oil that can be utilized now, with present technology and under present economic conditions. Resources, on the other hand, are potential reserves — they may become reserves under some improved condition of economics or technology or both. Economics includes such things as capital, incentive, profit, skilled labor, and political climate. Technology includes such things as know-how, concepts, machines, tools, methods, and principles.

The **reserves** we now have in the United States are computed annually and consist almost entirely of the recoverable oil and gas now in the oil pools and available for production under present economics and technology. They amount to over 30 million barrels or approximately 12 times our annual consumption. The resources of the



UPDIP WEDGE BELTS represent an important source of new oil. Importance of timing is clearly shown by comparing A and B. Oil migrated updip early in the region's history. Conceivably the downdip folds could be barren since they formed too late to trap the oil. Fig. 2.

Geological Outlook

United States and Canada, on the other hand, include such items as the undiscovered oil and gas, the so-called non-recoverable oil left in the ground after both primary and secondary methods have been applied, the tar and asphalt sands, the kerogen of "oil" shales, and coal. The relations and the relative amounts of each are shown in the chart, Fig. 1.

Notice that the conventional method of replacing our needs, listed as resource No. 2—Undiscovered Petroleum—is the only subdivision where geologists and geophysicists have a key place. Notice, also, the relatively large estimated quantities of other resources, some of which can start competing with conventional discovery with but a slight improvement in economics or a slight change in technology.

Our immediate concern as petroleum geologists and geophysicists, however, is with resource No. 2—the Undiscovered Petroleum, and how we may translate it into reserves.

Is it there to discover? . . . First, however, we must have some idea as to whether or not there is enough petroleum yet to be discovered to mean something in terms of the demand in years ahead. This becomes a matter of judgment, reason, and one might almost say, faith, because the undiscovered pool is unknown. One approach is to project ahead past performances and we see that we are now at our highest figures in both annual production and recoverable reserves. This suggests that our present provinces still contain a lot of oil and gas awaiting discovery. Whether these provinces contain a quarter, a half, or as much oil as has been discovered in the past is unknown, but in any case the undiscovered oil in present provinces must

THE AUTHOR

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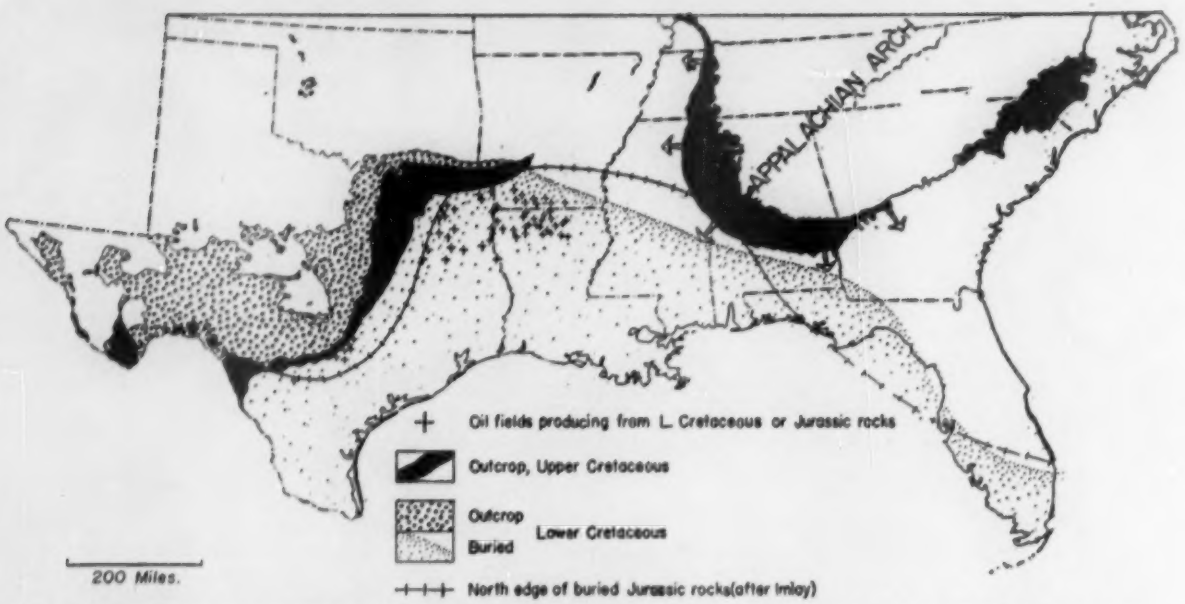


AN IMPORTANT FUTURE OIL PROVINCE occurs in the southeastern United States where Lower Cretaceous and Jurassic rocks wedge out against the buried Appalachian arch. Fig. 3.

Geological Outlook

represent a substantial amount in terms of future requirements.

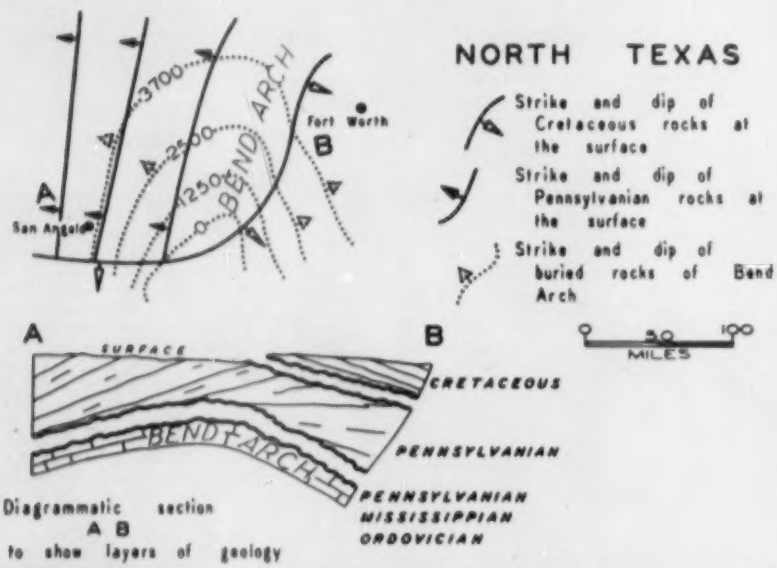
But in the future, as in the past, we cannot depend wholly on expanding our present producing provinces. We must continue to uncover new provinces in which many pools occur. When we look for new provinces, we are really moving far out into the unknown.

In spite of all this, however, we do have ways to think logically about the future. There always have been new provinces and new ideas of exploration coming up over the horizon. Some have materialized into great producing regions, while others have not fulfilled their early promise. And so it is now that a continuous procession of new ideas and potential provinces keeps coming into view—some probably to develop and some to fall by the wayside.

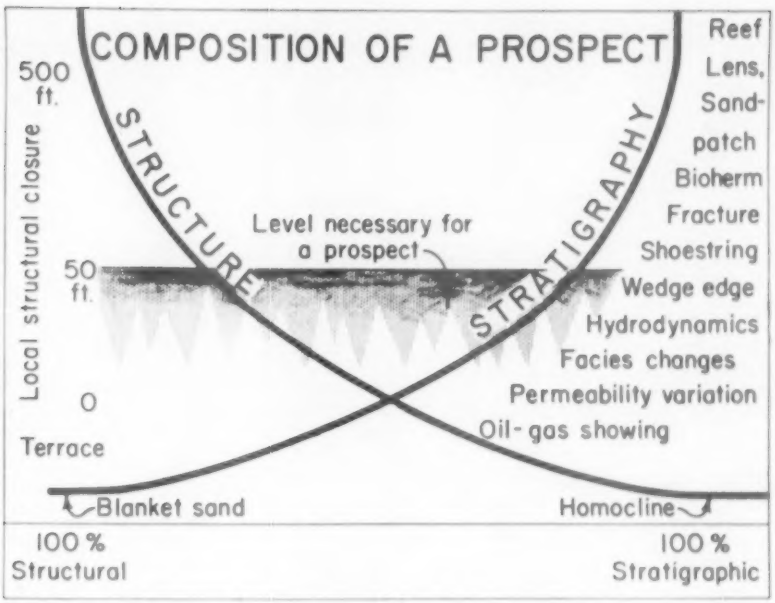
Three concepts . . . There are three general concepts that I believe illustrate the kind of geological thinking that will be necessary to effectively explore both the present and the future provinces. None is particularly new.

The **first concept** is the idea of the role of a regional, updip wedge-belt of permeability as a region where early migration enriches a reservoir rock and where later structural and stratigraphic phenomena permit a relocalization and concentration of the oil and gas into pools. The finding of one of these belts often leads to finding a petroleum province. The principle is illustrated in Fig. 2. The dotted area of "A" represents any permeable formation wedging up the dip, due to any cause. As soon as it is covered by an impervious shale or limestone, it becomes a regional area capable of trapping oil and gas that is migrating. At some later time, as in "B," local folding occurs in the wedge-out belt and the oil and gas become relocalized in local traps. Traps that form too far back from the edge are barren because the oil moved past them before they formed. This is the example of the practical importance of understanding the geologic history and timing of a region.

An area that is an example of such a wedge belt of permeability, and is unexplored, occurs in southern Alabama and Mississippi and possibly extends into Florida. There the south-plunging Appalacian arch crosses the updip wedge-out of the Lower Cretaceous and Jurassic formations along a belt that is 400 miles long and up to 100 miles wide, as shown in Fig. 3. These same rocks pinch out in northern Louisiana and northeastern Texas



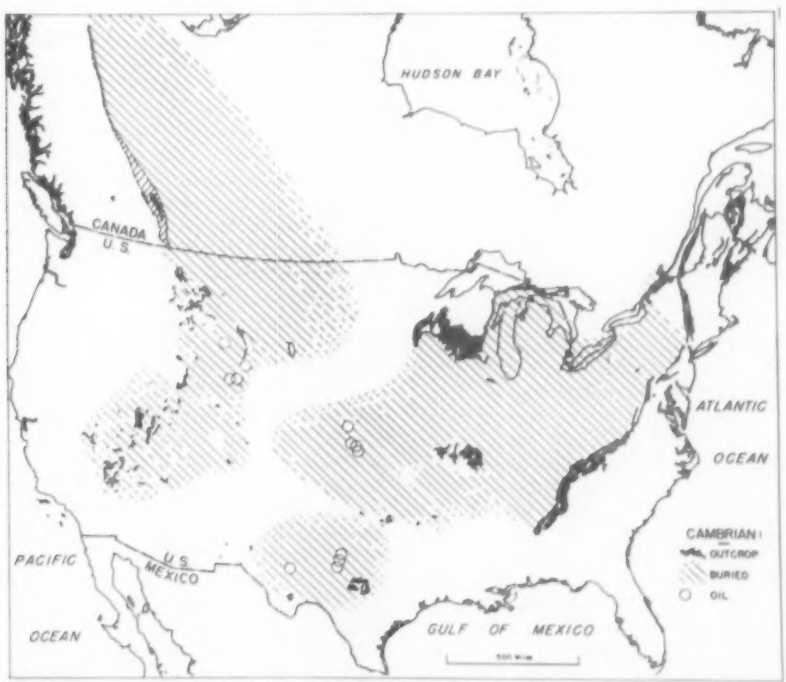
UNCONFORMITIES completely mask the underlying structures in the Bend arch region of Texas. Fig. 4.



FACTORS that make up a drillable prospect range from structure alone (extreme left of diagram) to stratigraphic conditions with no structural relief (right side). Fig. 5.

and there contain several hundred oil and gas pools. Whether this producing condition is repeated in Alabama and Mississippi, or whether there is one large combination stratigraphic and structural pool, as East Texas, but on an even more gigantic scale, cannot be guessed now. Recent discovery of oil in Lower Cretaceous rocks near Citronelle in southern Alabama, however, shows this region to be petroliferous and it could be large and rich.

The **second concept** concerns the importance of unconformities in the geologic section. All sorts of stratigraphic things happen both above and below a surface of unconformity and most of them are usually unpredictable in advance of drilling by any present method of petroleum geology



CAMBRIAN SEDIMENTS should prove to be excellent reservoir rocks. The shaded areas show the distribution of the Cambrian beds. Fig. 6.

or geophysics. Unconformity planes, in effect, separate the rocks into related groups or layers, and each layer has its own peculiar characteristics of oil and gas occurrence, velocity, stratigraphy and structure.

From an exploration standpoint, the important feature of these layers of geology is that until the surface of an unconformity is crossed, nothing is known about the conditions below. The example in Fig. 4 illustrates the effect of unconformities as masks that hide the underlying rocks in the Bend arch region of Texas.

There we see a Cretaceous section separated from the underlying Pennsylvanian rocks by an unconformity that also separates opposed dips. Each rock section has its own peculiar characteristics of geology. Below the Pennsylvanian come the older rocks, also separated from the younger by another unconformity. Each of these unconformities masks the rocks below and separates rocks, with their petroleum characteristics, into layers that cannot be anticipated until the drill had penetrated the unconformity surface.

The repeated discovery of new geological layers as the drill went deeper, for example, helped to keep the West Texas-New Mexico district alive and expanding through the last 30 years. The progressive discovery of new fields was in part due to the discovery of new rock layers separated by unconformities, and also to rapid facies changes in some of these layers.

In the Mid-Continent-Great Plains region, the progressive blackening of the map with new fields between 1932 and 1954 is reminiscent of the history of the West Texas region. And why not? Both regions contain similar unconformities, stratigraphy, kinds of oil, structure, and geologic history. The outlook throughout this great region, based on such reasoning, was never better.

The **third concept** that I believe is becoming apparent in the search for new pools is the relative increase in potential of stratigraphic traps and stratigraphic phenomena compared with purely structural traps. It is becoming more and more difficult to find large structural traps by any method, largely because exploration technology has been dominated by the search for structural traps. This is because (1) they are easier to find than stratigraphic traps, and (2) a single structure may contain several traps, one above the other, to be explored by a single well.

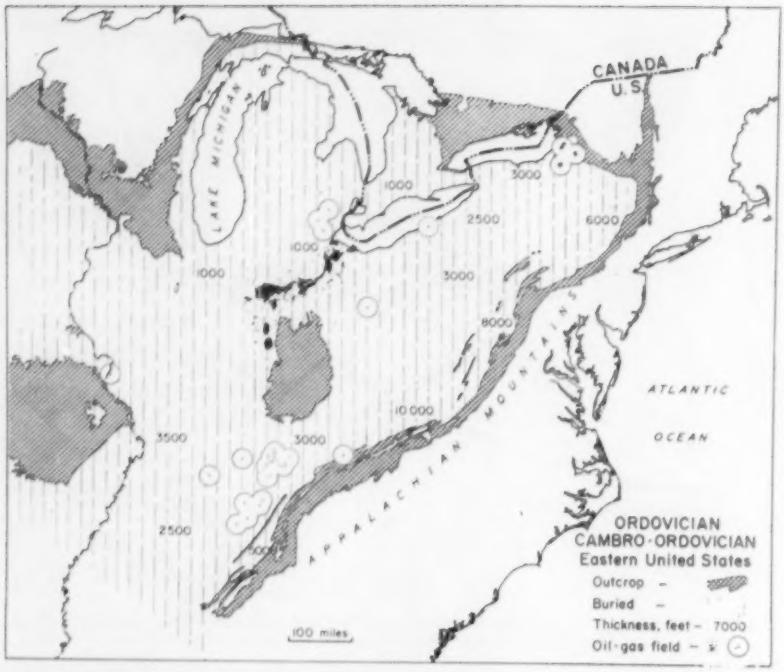
If we are running out of structural traps, however, it does not follow that

we are running out of oil, as some would lead us to believe. The largest deposits in North America—Athabaska, Pembina, and East Texas — are wholly or largely trapped by stratigraphic conditions. As in a great many other regions, such as the Appalachian geosyncline, Lima-Indiana field, or Hugoton gas field, none would be discovered by structural mapping alone. Nonstructural evploration undoubtedly has the peak of its importance a long time ahead.

Requirements for oil pools . . . If we examine almost any single oil pool we see that its presence at a particular spot is the result of the coincidence of some 20-30 variable factors. Structure, while generally of most importance, is but one of these variables. Others include such things as relative saturations of fluids; a source for petroleum; porosity; permeability; fracturing; hydrodynamics; fluid pressure; regional dip; the chemical and physical properties of the oil, gas, and water; geologic history; stratigraphy; uplift; erosion and overlap; unconformity surface; and the chemical and physical properties of the reservoir rock, including especially the clay content. The adverse development of almost any one, or any combination of several of these factors, is enough to keep what may appear to be an otherwise favorable spot, as barren or noncommercial. The petroleum geologist tries to determine as many of these factors as he can in advance of drilling.

The changing relation between structure and stratigraphy in the composition of a drillable prospect is shown graphically in Fig. 5 The level of data necessary for a prospect is shown between the 20 and 50-ft. local structure closure, for this zone marks the limit of instrumental error of seismic surveying and varies with different operators. Any local structure with more closure than this automatically becomes a prospect whether or not there are any known favorable stratigraphic or other factors present.

When the structural closure is less than 20 to 50 ft., however, stratigraphic and other factors become more and more necessary and must be added for an area to reach the level necessary to form a prospect. Finally, good prospects may occur where there is only a terrace structure or even a homocline provided a reef, a lens or patch of permeable sand, limestone, or dolomite can be located within an impermeable formation. Our hunting ground for drillable prospects is moving from the structural side of the chart into the stratigraphic side, where local structure plays a progressively lessening role.



CAMBRO-ORDOVICIAN rocks of the eastern United States are similar to their oil-bearing equivalents in the Mid-Continent, the Ellenburger-Arbuckle, Simpson, and Viola. Fig. 7.

The location of these stratigraphic and related phenomena has heretofore been largely the result of applied stratigraphy and has depended in part upon geophysical data obtained from electric and radiation logs, drill-stem tests, pressure-buildup curves, and dipmeter surveys. As for the other, and possibly more conventional geophysical techniques, it seems to me that locating these stratigraphic features may be beyond the scope of either magnetic or gravity surveys. Their location, however, is within the realms of advanced and careful seismic surveys, even though much of the modern seismic surveying is not concerned with such detailed phenomena.

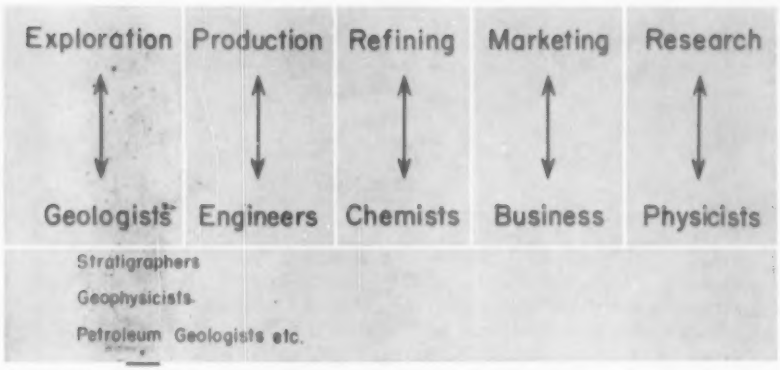
Strat traps a vital problem . . . I think we must recognize that finding traps that combine variable stratigraphy with low structural relief, or even no local structure, is one of the most important exploration problems facing us in the future. It is up to petroleum geologists, stratigraphers, and geophysicists to develop methods of locating these stratigraphic anomalies with a minimum of drilling.

This is an area where close cooperation among different phases of geology has a much better chance of becoming the key to success than does lone-wolf competition. It is a place where the petroleum geologist needs more geophysics and the geophysicist needs more stratigraphy.

The Cambrian and Cambro-Ordovician rocks of the United States offer an interesting example of a large region where these concepts of oil occurrence may apply. Fig. 6 shows the distribution of the Cambrian in the United States and areas where production has been found in Cambrian rocks.

Whether one believes the oil found in the Cambrian is indigenous to the Cambrian or not, there are so many places where unconformities, overlaps, truncations, and erosion have exposed Cambrian rocks to younger sediments, that leakage into the Cambrian from these supposedly more petroliferous rocks, could account for large sources of supply. Cambrian sediments seem ideal as reservoir rocks.

The Cambro-Ordovician of the eastern United States is shown in Fig. 7. These rocks are the equivalent in age and character to the Ellenburger-Arbuckle, Simpson, and Viola formations of the Mid-Continent. They range in thickness up to 10,000 ft. and contain lateral variations in permeability, irregular dolomite patches, widespread unconformities, oil and gas deposits, and folding and truncation — all of which characterize the equivalent oil-bearing rocks of the Mid-Continent. Relatively few wells have penetrated this group of rocks and they appear to offer many chances for the discovery of pools, fields and provinces; possibly on a large scale.



MEN WHO ARE SPECIALLY TRAINED in their company's field of endeavor normally guide the company's efforts. Geologists head up exploration companies. Engineers are in charge of producing companies, etc. Fig. 8.

Geological Outlook

But, if we believe the oil is underground, yet cannot discover it, of what use is it? We are no better off than the Arab of the Middle East before the American oil finders arrived on the scene. This brings us up to the third question for an answer:

How Can We Discover It?

There are two commonly known developments here in the United States that seem to me to insure the eventual discovery of the bulk of the oil now hidden underground. These are (1) the fact that in our American system we are able to apply a multiple competitive effort to our exploration, and (2) the efficient organization of our manpower.

1. Multiple effort . . . The importance of multiple effort as a way of successful exploration was first mentioned by DeGolyer, I believe, and is now a solid base to our whole philosophy of exploration. Over and over again pools have been discovered that were passed up by other explorers—some because of better interpretation of the drilling data, some because of better interpretation of the structure and consequently a better location than previous wells, some because of better interpretation of the stratigraphic conditions underground, and some because of theories contrary to the prevailing ideas. The successes that follow failures generally come from better interpretations of data that are available to all.

The effect of multiple effort also reaches into many of the details of exploration. Nearly every electric well log, for example, because it is generally available for study, is examined through many years by dozens of individuals, each with a different background of experience and ability, and each with an incentive to find a new pool of oil or gas. As a result, just about every scrap of information is eventually squeezed out of the log before it is shelved; that is, if it ever is put away for good.

The same applies to most other geological and geophysical data such as sample logs, drillers' logs, drill-stem-test records, pressure-buildup curves, dipmeter surveys, well elevations, and core analyses, and this accounts in large measure for the general effectiveness of our exploration.

If multiple effort is so effective as a way of exploration, then the usefulness of other geophysical data can be greatly increased by the development of some kind of free exchange or interchange of basic, raw seismic, gravity, and magnetic data. These data are now filed away in storage rooms where they are carefully guarded against prying eyes; they have become virtually classified information. If these old seismograms could be as readily available for study by as many interpreters as well logs, for instance, there is no question but that the rate of discovery would be increased.

2. Manpower organization . . . The second peculiarly American development that contributes to our exploration effectiveness is what might be called the **ability equilibrium** that is present in nearly all oil company organizations. By that I mean that in our free system every person has the opportunity to reach any place his ability will carry him, regardless of his money, school, religion, or color. It is like sifting sand through a Ro-Tap screen—each grain comes to rest at the mesh level its size calls for.

In a free system, we see that modern oil-company research, for example, is run or managed by persons with a background training in physics; marketing is run by business-trained individuals; refining is managed by chemists, production by engineers; and exploration is guided and managed by geologists. Fig. 8 shows the relation graphically.

The failure of much nationalized foreign exploration, for example, lies in the fact that laws so often require that the exploration be done by engineers. An engineer presumably deals in equations and facts; imagination is a handicap to him, as it would be to a surgeon. One way to ruin an oil pool would be to let an imaginative geologist produce it, and by the same reasoning, one way to assure failure in an exploration program is to let an objective engineer manage it—for he would never find numbers to put into his equations.

The geophysicist, likewise, is a specialized worker and thinker—his problem is to obtain accurate measurements of rock properties and attitudes in advance of drilling. Imagination is a handicap here also. All three represent necessary but different kinds of thinking and these differences qualify each to do a specific job. A familiar analogy is the hospital where doctors include specialists in diagnosis, surgery, and X-ray.

Conclusions

In conclusion, we may say this about the geological outlook:

1. A continuation of the growing demand for petroleum seems assured. All of us in petroleum exploration have a big job ahead.

2. There appears to be an abundance of unexplored rocks in which to search for new petroleum deposits in the conventional manner.

3. Other resources with large potential may become reserves with slight changes in either technology or economics, or both. Of these the most important seems to be the possibility of changing more of the "non" in "non-recoverable" into "now." This possibility seems to be the most serious threat to geologists—both petroleum geologists and geophysicists—because our area of usefulness is in the discovery of new deposits, not the more efficient extraction of oil from past discoveries.

4. The discovery of most of the undiscovered deposits is assured, provided we maintain the incentive and the freedom to apply a multiple effort to the search, and as long as our exploration organizations are permitted to develop naturally and maintain an equilibrium of ability; that is, the best man for the job.

5. And finally, anyone who says the oil of the future will be discovered by petroleum geologists without geophysics, or who says the oil will be discovered by geophysicists without structural, stratigraphic, and fluid geology, is talking through his hat. All who deal with the earth, **ge** and its science, **logy,** are geologists.

Geophysics Is Here to Stay . . .

. . . only if it finds oil at a price the industry can afford to pay

by Holland C. McCarver

WHAT is the geophysical outlook? Each one of us should ask himself this question and then ponder over his answer. What is the outlook of geophysics? Have the seismograph, the gravity meter, and the magnetometer passed their heyday? Will the number of crews in the field decline from this point onward? Certainly not, I think. The more difficult oil is to find, the more necessary geophysics **should** become. But geophysics will remain necessary **only** if it **finds** oil and at a price the industry can afford to pay. An article in a current issue of a petroleum journal, for instance, gives a statement by a geologist which says "The drilling rig is the best exploration tool we have, and possibly the most economical under normal conditions." This statement points with emphasis to what I am trying to say. Geophysical methods must continue to add to our oil reserves at a rate more favorable than nongeophysical methods, or geophysics will not be used.

Technical advances . . . New developments in the geophysical field in the past few years have been excellent. The seismograph in particular has taken great strides in offering new and useful techniques. The multiple shot-hole and multiple seismometer systems have improved record quality in tough areas; plotting techniques have aided greatly in cross-section studies; continuous velocity logging and high resolution-high frequency crews have established themselves; and the tape systems with the removal of elevation, stepout, and weathering offer tremendous advantages over older equipment in the acquisition of data. These new advances, and the ones that will come in the future, will aid greatly in the search for oil if we use them properly.

We must remember, however, that no system is truly automatic. Every effort should be made in the field to get maximum use from the equipment on the crew, whether new or old. What is done later in laboratory or office is entirely dependent upon the ability of field personnel to furnish high-quality data. Automation in itself is thus not a cure-all.

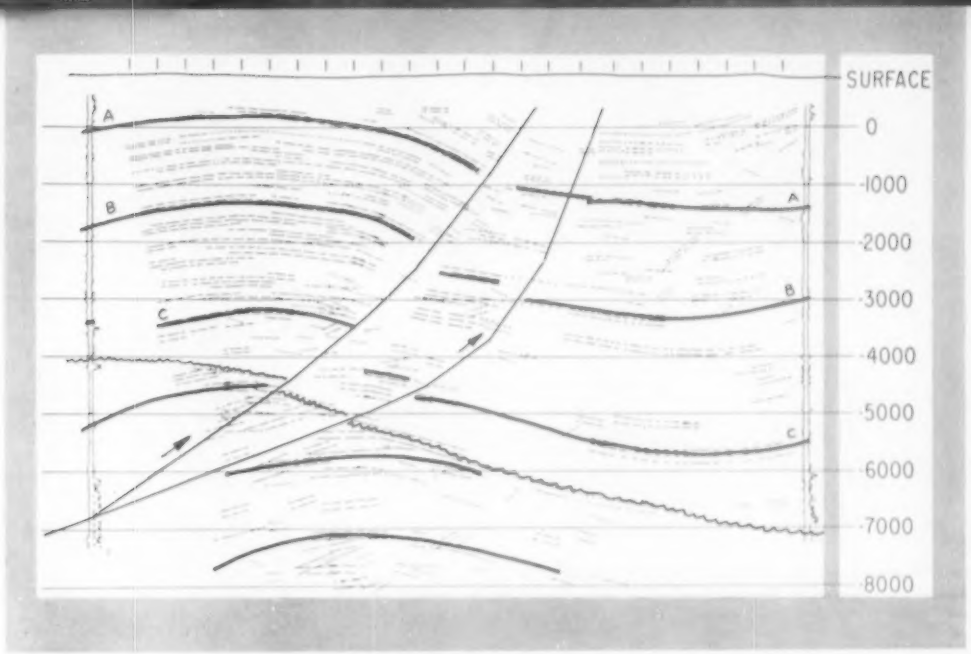
Economics . . . In fact, the first result that some of us see as these new techniques are adopted is a steep increase in our geophysical invoices. Any noticeable increase in oil-finding efficiency often lags far behind.

It is realized that these new advances are good and that they cost money. Sometimes, however, the chief geophysicist or the director of exploration must appear to his management to be a fast-talking evader of the truth, for the time required for results to catch up with costs is often agonizingly long. And if they don't catch up, this company or that suddenly announces a redeployment of high-level personnel.

Seriously, though, increased geophysical costs are of great concern throughout the exploration industry. This is particularly true when viewed with the **decrease** in the barrels of oil discovered per crew-months worked.

When at all practicable, crew costs must be kept at a level low enough to fit the budgets of as many exploration departments as possible. New and advanced equipment should be added not because it is available but because it is necessary to improve results. Multiple-hole and multiple-seismometer crews should not be used in good single shot-hole country. Tape and disk recorders should be used selectively and not at random. It must be remem-

SEISMIC CROSS-SECTION showing reflection data migrated and plotted in time. Although the data are abundant and of good quality, they are difficult to integrate with geological information which is available in feet. Fig. 1.



SAME SEISMIC SECTION shown in Fig. 1 but now plotted in feet, carrying electric-log information and showing a geological-geophysical structural interpretation. This display offers accuracy, usability, and salability not found in the time section. Fig. 2.

Geophysical Outlook

bered that geophysical budgets will remain high only if we find oil—not because we build new and costly equipment.

Personnel . . . Lagging behind technical advances and increased costs is the development and use of geophysical personnel. Much has been done in recent years to interest students in the field of geophysics and much high-quality personnel has been added to the industry.

Classification of this personnel, however, sometimes seems to be missing. Every effort should be made to recognize staff personnel and line personnel and place them in their proper positions. All too often it seems that a Ph.D. in mathematics is a party chief and a man with the unique assets of a party chief is plotting wave-front charts and preparing velocity reports.

In a recent experience with a new advance in seismic instrumentation, a chief geophysicist was amazed and greatly gratified at the tremendous improvement in the results obtained with the new technique. The new method produced so much more information than a conventional survey had 5 years before, that not enough good could be said about it. In the course of combining the older survey with the new one, however, the current party chief reworked some of the older data. the results were amazing. In the final analysis, it was the party chief who had contributed at least 70 per cent of the improvement observed—the new technique, 30 per cent or less.

The right man in the proper job can produce, even with older data and older equipment. The wrong man can not produce with the best methods.

Application . . . Our most glaring shortcoming, I believe, lies in the failure of the geologist to apply available geophysical data to the solution of his problems; or, to put it the other way, the failure of the geophysicist to obtain and use all possible geological information when making his interpretation. Since neither really excels in the other's field, however, the best effort by far can be made by the geophysicist and the geologist working **together.** And since teamwork will produce the most reliable and comprehensive subsurface interpretations, the two should work together from the inception of any exploration project.

The geologist should describe in detail the object of the proposed survey, the key target horizons, and the type of structural features anticipated. The geophysicist should suggest and discuss with the geologist the methods and techniques best designed to solve the questions presented. One cannot be very critical of an effort in which he is a participating partner, and partnership efforts pay off. Also, enthusiastic geological-geophysical partnerships produce **new ideas** and new ideas **find new oil.**

Since these comments are aimed primarily at us geophysicists, what can we do to bring about more effectively this exploration partnership? How can we so woo the geologist that he will want to be our partner? How can we make the seismic cross-section, for instance, as attractive and as necessary to his work as the electric log?

First, let us tear away the veil of mysticism—and skepticism—that seems to hang between many geologists and anything related to geophysics. Remembering that this veil is partly of our doing, why don't we throw open our door and say, "Look fellows, this geophysics is no witchcraft science. It is relatively simple; here is the way it works; and here is how it can be used to your advantage." And if the geologist doesn't come to us, we ought to go after him. Along this line, it would be a forward step if some of the larger companies and contractors would give a short course in geophysics for geologists. I mean a practical course, something like the one offered by Schlumberger in the study of electric logs. We've got a good oil-finding method—let's sell it!

A discussion of a good sales program might include some of the following ideas. For expediency here the ideas

THE AUTHOR

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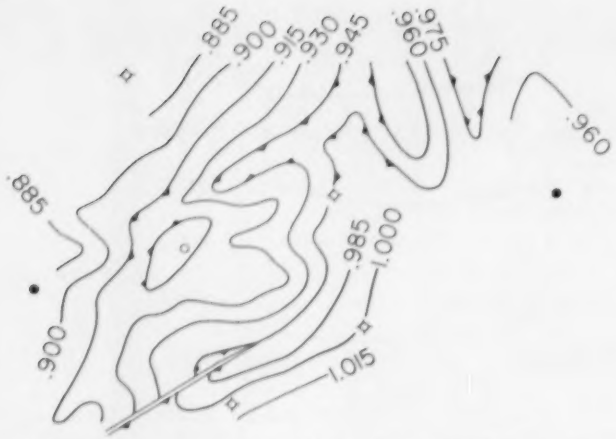
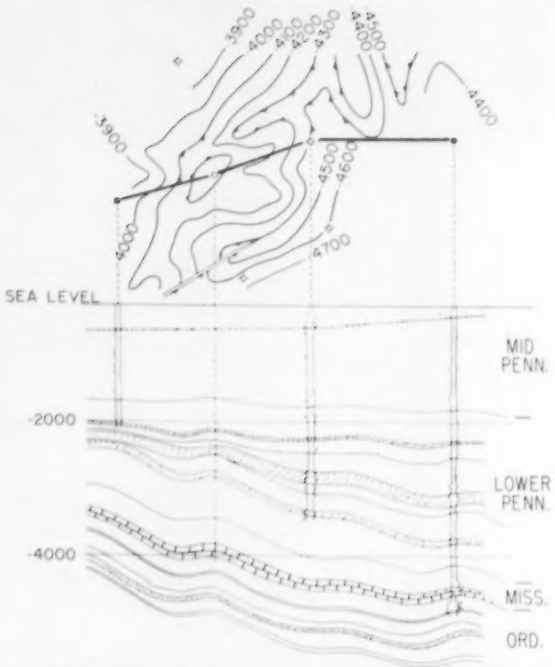


SEISMIC MAP contoured in time showing test wells and structural possibilities. Fig. 3.



SAME SEISMIC MAP contoured in feet combined with a geophysical-geological cross-section. The coordination of geophysical and geological data allows a presentation showing structure, stratigraphy, lithology, and regional dip. Fig. 4.

Geophysical Outlook

presented concern the seismograph, but similar approaches can be made with all geophysical methods.

All seismic cross-sections should be plotted in **feet** rather than in time. Sure, your velocity control might be weak and your plotted depth points somewhat in error, but a section plotted in feet will be used, and one plotted in time will be thrown back into the file. Geologists do not think in terms of seismic time.

And on sections plotted in feet, you can superimpose electric logs to scale whenever a well is tied into your survey. These reduced logs are quite legible and do much toward getting the geologist to join the geophysicist in cross-section studies.

By placing carbon paper face up under sections when they are plotted, sharp contrast is obtained and good field prints can be made. Since these printed sections carry much more information than a contour map, copies should be made available to all geologists concerned with the project being worked. People can't help being interested when they receive information and understand it.

The above remarks are also applicable to seismic maps. Contour your maps in feet—not in time! Show as much information on them as possible and see that prints reach all concerned. Constructive criticism is much more helpful than just plain criticism.

A few illustrations are included which show some of the points just made.

Shown in Fig. 1 is a seismic cross-section plotted in time. Reflection data are good and rather abundant, but structural complications are quite evident. A party chief, with even more than a passing knowledge of the geology of the area, would have an extremely difficult task in interpreting correctly the information shown here. And a geologist, attempting an independent interpretation, would be confronted with data he doesn't wholly understand—or trust—plotted in unfamiliar seismic time.

A much more understandable presentation is shown in Fig. 2. Electric logs, from wells located on the line of survey, have been added to the cross-section, now plotted in feet, and the interpretation shown has been made by the geologist and geophysicist working together. Joint subsurface interpretations, such as this, certainly contain more accuracy than individual efforts; and I think it is obvious which interpretation you would present your management to "sell' a play.

Fig. 3 is an example of a seismic map contoured in time showing the type of presentation obtained from the study of time sections.

Fig. 4, however, is a combined geophysical-geological display which is obviously more informative than the map just shown. Presentations like this can be made easily and accurately from studies of comprehensive geophysical-geological cross sections, such as shown in Fig. 2. The display in Fig. 4 carries information concerning structure, stratigraphy, regional dip, unconformity and target horizons that can not be seen on the map just shown. If you represent geology, geophysics or management, which map would you prefer?

If any of you are concerned about geologists' learning and misapplying a small amount of geophysics, please don't be. If we emphasize partnership effort and present our data completely and understandably it won't be misused; and the geologist is no more interested in the intricacies of geophysics than you are in the foraminifera of the Lower Tertiary. He just wants to use your product—if you make it available to him.

To worry unduly about the geologist and to consider him as opposition in our current exploration effort reminds me of Ben Franklin's Tradesman who said of a dispute among friends, "Till late I could scarce believe the story of him who refused to pump in a sinking ship because one on board whom he hated would be saved by it as well as himself."

We haven't reached this extremity, of course. There has been integration of geology and geophysics since the day of the first geophysical crew, and this integration has improved in spirit and in fact since that time. What we now seek is a better and more complete coordination of geology and geophysics so that the data from each science may be used to its utmost.

Let's get smart, get together and get to work—and we'll find oil.

"THE HABITAT OF SOME OIL"

Where Are the World's Giant Fields?

The authors say . . .

- The stable side of a basin holds most of the basin's oil
- Anticlines account for 80 per cent of the free world's oil
- Sand reservoirs hold 59 per cent of oil found in major fields
- Mesozoic and Miocene-Oligocene rocks are principal oil producers

by G. M. Knebel and Guillermo Rodriguez-Eraso

ANY study involving the world's major oil fields carries considerable weight in view of the impressive aggregate ultimate recovery that these fields have. Consequently, these major accumulations provide the geologist with the easiest accessible means of studying the bulk of the world's oil found to date.

The world's habitat-of-oil picture can be viewed from as many angles as there are relevant controlling geologic factors. In this statistical study, the information relating to the habitat of oil in the free world's major oil fields will be presented on the basis of the following criteria:

1. Geographical location.
2. Basin position:
   - Depositional basin:
     - (a) Mobile rim
     - (b) Deep basin
     - (c) Hinge line
     - (d) Shelf
   - Present (structural) basin:
     - (a) Mobile rim
     - (b) Deep basin
     - (c) Hinge line
     - (d) Shelf
     - (e) Other
3. Type of trap:
   - (a) Anticline
   - (b) Fault
   - (c) Unconformity
   - (d) Reef
   - (e) Other stratigraphic
   - (f) Combination
4. Lithology of reservoir:
   - (a) Sand
   - (b) Carbonates
   - (c) Other fracture
5. Geologic age of reservoir:
   - (a) Pleistocene-Pliocene
   - (b) Miocene-Oligocene
   - (c) Eocene-Paleocene
   - (d) Mesozoic
   - (e) Paleozoic
6. Gravity of crude:
   - (a) Light (above 30° A.P.I.)
   - (b) Medium (22°-30° A.P.I.)
   - (c) Heavy (below 22° A.P.I.)
7. Chemical base of crude:
   - (a) Paraffinic
   - (b) Mixed
   - (c) Asphaltic
8. Subsurface depth of occurrence:
   - (a) 0- 1,000 ft.
   - (b) 1,000- 2,000 ft.
   - (c) 2,000- 3,000 ft.
   - (d) 3,000- 4,000 ft.
   - (e) 4,000- 5,000 ft.
   - (f) 5,000- 6,000 ft.
   - (g) 6,000- 7,000 ft.
   - (h) 7,000- 8,000 ft.
   - (i) 8,000- 9,000 ft.
   - (j) 9,000-10,000 ft.
   - (k) 10,000-11,000 ft.
   - (l) 11,000-12,000 ft.
   - (m) over 12,000 ft.
9. Time of discovery

Once a field was properly classified according to the subdivisions of the above scheme, the next step consisted in assigning ultimate reserves to every one of the classifications pertaining to each field. Finally, the allocated reserves figures of the individual fields were totaled for each basin in order to arrive at totals for each continent and for the free world as a whole. In addition, under each classification, the number of fields was also totaled in order to gain an idea of how many individual occurrences were responsible for the reserves calculated in the previous step.

Only 236 fields qualify as "major" . . .

"The Habitat of Oil in the Sedimentary Basin" was the central theme of the annual meeting of the American Association of Petroleum Geologists held in New York during March 1955. At that meeting, numerous excellent papers were presented covering many of the producing basins of the world. As a follow-up of those presentations, this paper offers a statistical study of the habitat of most of the world's ultimate oil discovered to date outside Soviet Russia and its affiliated countries.

For practical reasons, this study deals only with the so-called major fields, those fields having an ultimate recovery exceeding 100 million barrels. Ultimate recovery, as used in this paper, means total oil discovered to date, that is, present remaining reserves plus past production. During the study, it was found that 236 fields qualified as major oil fields. These fields are located in 42 basins and together account for 217 billion barrels of oil. This represents 82.5 per cent of the known ultimate recovery of the free world of approximately 263 billion barrels. The remaining 17.5 per cent, or 46 billion barrels, is scattered in thousands of smaller fields whose individual recoveries will not reach 100 million barrels.

Geographical Location

Before going into the geologic details of the study, a few generalities on the geographical location of these giant fields and the basins in which they occur will be shown in Tables 1 and 2.

As Table 1 shows, North America leads the way in total number of major fields while the Middle East shows the highest average ultimate yield per field. This table also indicates that 185 fields, or 82 per cent, fall in Class 1, the smallest bracket, of the breakdown having ultimate reserves of less than 500 million barrels each. The true

TABLE 1—DISTRIBUTION OF MAJOR FIELDS BY AREA AND SIZE

Area—	Number of major fields— Total	Class 1	Class 2	Class 3	Class 4	Average ultimate (million bbl.)
North America	177	153	19	5	0	300
South America	28	22	5	0	1	730
Europe	1	1	0	0	0	120
Africa	1	1	0	0	0	200
Middle East	21	2	6	8	5	6,700
Far East	8	6	1	1	0	520
Free world	236	185	31	14	6	920

Class 1—Fields with 100-500 million barrels ultimate. Class 2—Fields with 500-1,000 million barrels ultimate. Class 3—Fields with 1,000-10,000 million barrels ultimate. Class 4—Fields with over 10,000 million barrels ultimate.

TABLE 2—DISTRIBUTION OF BASINS WITH MAJOR OIL FIELDS BY AREA AND NUMBER OF FIELDS PRESENT

Area—	Number of basins (major fields)— Total	0-5 Class 1	5-10 Class 2	10-20 Class 3	Over 20 Class 4
North America	28	20	2	5	1
South America	6	4	1	1	0
Europe	1	1	0	0	0
Africa	1	1	0	0	0
Middle East	1	0	0	0	1
Far East	5	5	0	0	0
Free world	42	31	3	6	2

giants with reserves over 10 billion barrels each are confined to the Middle East with the exception of one located in western Venezuela. In the Middle East 13 fields, or 56 per cent of the total of 21 fields, have ultimates exceeding 1 billion barrels each, and of these, five fields, or 38 per cent, have an ultimate yield in excess of 10 billion barrels.

The world-wide distribution and relative importance of the privileged basins having major oil fields are shown by Table 2.

This table shows that only eight basins in the world have over 10 major fields each. It should be noted that 31 basins, or 74 per cent of the total, belong to Class 1 having five or fewer fields. Of the total of 42 basins having major oil fields only 2, the Persian Gulf and the Gulf Coast. have more than 20 major fields among their petroleum accumulations.

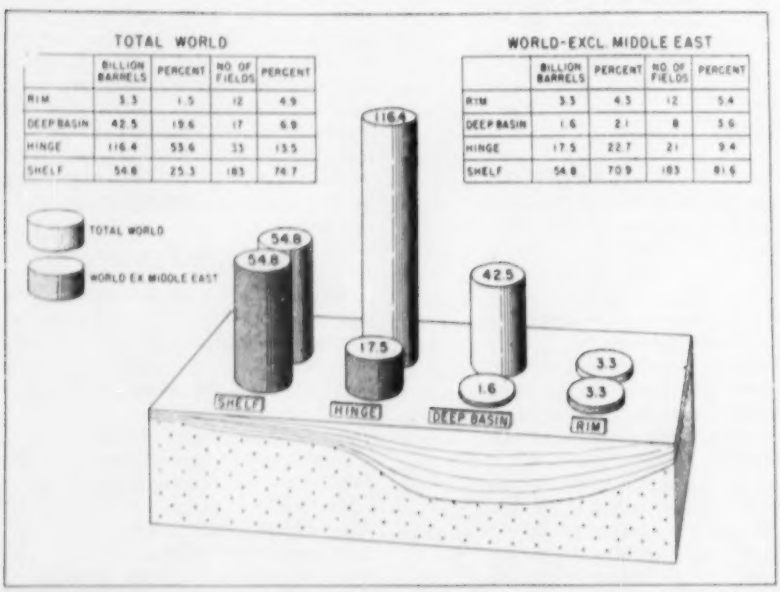
Position in the Depositional Basin

Fig. 1 shows schematically the four simplified portions of a basin which were used in this work, namely, the shelf, hinge line, deep basin, and mobile rim. If a more elaborate breakdown had been used, the results would be more difficult to interpret even though they might more nearly conform to the architecture of basins as understood today.

There may be some question as to the basin position assigned to some of the fields. The authors believe that the selections made are reasonably correct and should be accepted until a more exhaustive study is made. It should be emphasized, however, that there is usually less room for argument regarding the fields' basin position in the present or structural basin. Therefore, the position in the structural basin is considered more reliable and should be the criterion used to indicate the basin habitat of oil.

In the figures and tabulations that follow, two sets of figures will be shown. One set applies to the free world as a whole while the second will give the free world's picture excluding the Middle East. This is necessary because the tremendous reserves of the Middle East often distort the picture of the habitat of oil in the other areas.

It should also be noted than on each figure the entries under the "Number of Fields" column represent the number of individual occurrences recorded for each particular tabulated criterion. Due to the fact that many fields have to be classified under more than one of the



OVER 50 PER CENT of the ultimate reserves of the major fields studied are located along the hinge lines on the depositional basins. Fig. 1.

Habitat of Oil

THE AUTHORS

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Knebel is outgoing president of the American Association of Petroleum Geologists. This paper, under the original title, "The Habitat of Some Oil," was given before numerous geological societies and other groups on his presidential tour during 1955 and 1956. It appears in the current issue of the A.A.P.G. Bulletin and is presented here by permission of the A.A.P.G.

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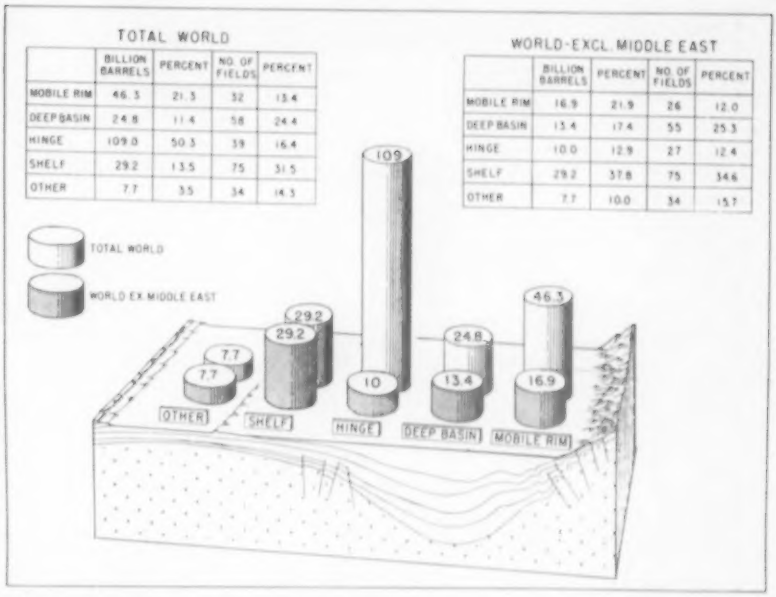
criteria used, there is a certain degree of overlap and the sum total of the individual occurrences listed is always greater than 236, or the total number of fields.

Fig. 1 presents, numerically and graphically, the distribution in the depositional basin of the ultimate oil discovered to date in the free world's major oil fields. This figure shows that over 50 per cent of the ultimate reserves of the major fields studied are located along the hinge lines of the depositional basins. It should be noted, however, that if the prolific Middle East fields are excluded, the shelf becomes the leader in both ultimate oil and number of fields.


TOTAL WORLD
BILLION BARRELS | PERCENT | NO. OF FIELDS | PERCENT
MOBILE RIM 46.3 | 21.3 | 32 | 13.4
DEEP BASIN 24.8 | 11.4 | 58 | 24.4
HINGE 109.0 | 50.3 | 39 | 16.4
SHELF 29.2 | 13.5 | 75 | 31.5
OTHER 7.7 | 3.5 | 34 | 14.3
WORLD-EXCL MIDDLE EAST
BILLION BARRELS | PERCENT | NO. OF FIELDS | PERCENT
MOBILE RIM 16.9 | 21.9 | 26 | 12.0
DEEP BASIN 13.4 | 17.4 | 55 | 25.3
HINGE 10.0 | 12.9 | 27 | 12.4
SHELF 29.2 | 37.8 | 75 | 34.6
OTHER 7.7 | 10.0 | 34 | 15.7
TOTAL WORLD
WORLD EX MIDDLE EAST
109
46.3
29.2
29.2
24.8
7.7
7.7
13.4
16.9
10
OTHER
SHELF
HINGE
DEEP BASIN
MOBILE RIM

IN THE PRESENT or structural basin, the hinge line still accounts for roughly 50 per cent of the recoverable reserves. Fig. 2.

Rim fields . . . Fields located along rims of depositional basins are present in the Rocky Mountains and the Mid-Continent region of the United States and in the Orinoco basin of eastern Venezuela and Trinidad.

Deep-basin fields . . . Deep-basin fields are more widespread than rim fields and occur in the Ardmore basin of southern Oklahoma, some of the California basins, West Texas, and the Middle East.

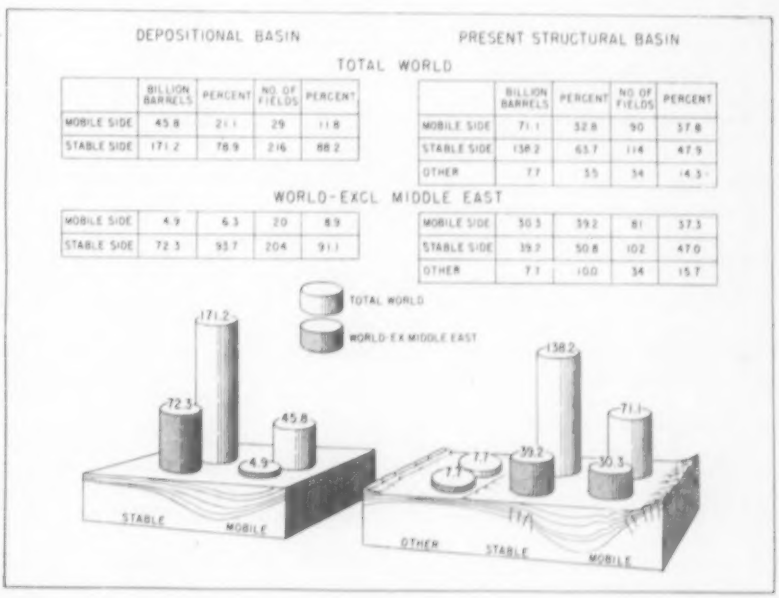
Hinge-line fields . . . Hinge-line fields in North America are limited to the Alberta, Ardmore, Gulf Coast, and Appalachian basins. In South America, important hinge-line fields are found in the Maracaibo basin of western Venezuela and the Comodoro Rivadavia basin of southern Argentina. The greatest bulk of the Middle East oil is localized along the hinge line of the Persian Gulf basin. All of the known producing fields of southern Iraq, Kuwait, Saudi Arabia, Bahrain, and Qatar lie along the basin's hinge line with an estimated ultimate of close to 100 billion barrels.

Shelf fields . . . Of the 42 basins having major fields, all but 7 have fields along the shelf of the depositional basin. The three most important domestic areas from the standpoint of ultimate reserves from the shelf are the Gulf Coast, California, and West Texas. Elsewhere, important shelf reserves are found in the Alberta, Northeast Mexico, Maracaibo, Orinoco, and Central Sumatra basins.

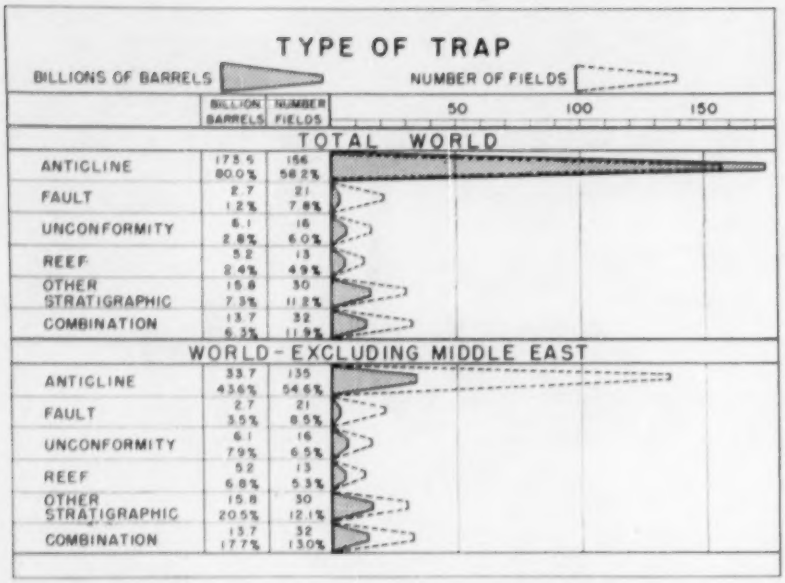
Position in the Present (Structural) Basin

Fig. 2 shows the basin habitat in the present or structural basin of the oil from the free world's major oil fields. It should be noted that a fifth category has been added to the basin's subdivisions. Under this "other" category are classified those fields which cannot be associated with any present-day structural basin. The fields included here are all located in the United States and are all intimately related to large tectonic features such as the Central Kansas uplift, Nemaha ridge, Cincinnati arch, etc.

Upon examining the figures, it can be seen that the hinge line still accounts for roughly 50 per cent of the recoverable oil of the fields being considered. The mobile-rim province has increased to 21 per cent of the total at the expense of the reserves of both the deep basin and the shelf. Again here, if the Middle East is excluded, the shelf occurrence would predominate in both reserves and number of fields. It is to be noted, however, that the commanding position of the shelf province is not as marked here as it was in the case of the depositional basin. The difficulty of recognizing a hinge line in many present-day basins may account for the relatively small number of fields under the hinge.


DEPOSITIONAL BASIN
PRESENT STRUCTURAL BASIN
TOTAL WORLD
BILLION BARRELS | PERCENT | NO. OF FIELDS | PERCENT
MOBILE SIDE 45.8 | 21.1 | 29 | 11.8
STABLE SIDE 171.2 | 78.9 | 216 | 88.2
MOBILE SIDE 71.1 | 32.8 | 90 | 37.8
STABLE SIDE 138.2 | 63.7 | 114 | 47.9
OTHER 7.7 | 3.5 | 34 | 14.3
WORLD-EXCL MIDDLE EAST
MOBILE SIDE 4.9 | 6.3 | 20 | 8.9
STABLE SIDE 72.3 | 93.7 | 204 | 91.1
MOBILE SIDE 30.3 | 39.2 | 81 | 37.3
STABLE SIDE 39.2 | 50.8 | 102 | 47.0
OTHER 7.7 | 10.0 | 34 | 15.7
TOTAL WORLD
WORLD EX MIDDLE EAST
171.2
138.2
72.3
45.8
71.1
4.9
7.7
39.2
30.3
7.7
STABLE
MOBILE
OTHER
STABLE
MOBILE

THE STABLE SIDE of the basin holds the most oil. Notice the size of the Middle East reserves. Fig. 3.



ANTICLINES account for 80 per cent of the recoverable reserves. Even with the Middle East fields excluded, the anticlines are still the most important oil trap. Fig. 4.

Rim fields . . . Fields located on the mobile rim side of the present-day-structural basins are found chiefly in the following areas: Rocky Mountains, California, Venezuela, and Middle East.

Deep-basin fields . . . Deep-basin fields occur mostly in Canada, the Mid-Continent area, California, and the Gulf Coast. Substantial reserves are also found in the deeper portions of the Persian Gulf basin.

Hinge-line fields . . . Hinge-line fields in the United States are found mainly in the Gulf Coast and California. In South America both Venezuela and Argentina have important hinge-line accumulations. The Middle East carries again close to 100 billion barrels of ultimate reserves in fields located along the hinge line of the Persian Gulf basin.

Shelf fields . . . Major shelf fields are reported from 21 basins, of which the ones having in excess of 1 billion barrels ultimate, are listed in diminishing order: Gulf Coast, West Texas (Midland and Delaware basins), Northeast Mexico (Tampico embayment), Alberta, Central Sumatra, Maracaibo, Los Angeles, and Orinoco.

Basin habitat in summary . . . In an attempt to summarize the previously discussed basin habitat of oil, Fig. 3 presents the same data in a more simplified manner. In the preparation of this breakdown the shelf and hinge-line occurrences have been grouped together and a total for the stable side of the basin was obtained. In the same manner, the deep-basin reserves were added to the ones belonging to the rim in order to get a total for the more mobile side of the basin.

This figure clearly shows that the stable side of the basins holds most of the oil. The data indicate that in the depositional basins, discovered reserves to date in the stable side are nearly four times those of the mobile side. In the present-day basins the mobile side has an improved position, but still the stable side leads the way by an approximate two to one margin. The fact that the above pattern of distribution holds true for both the depositional and structural basins, is considered significant.

Type of Trap

Fig. 4 is a breakdown in billions of barrels and number of fields according to the type of trap responsible for the oil accumulations in the fields included in the study.

Anticlinal lead . . . It will be noticed that anticlinal traps are a clear leader accounting for 80 per cent of the total oil found to date in the free world's major oil fields. Many of these anticlines are faulted, but in all cases listed under "anticline"; the primary element causing the accumulation is the structural folding.

The greatest anticlinal province is, of course, the Middle East where close to 140 billion barrels of oil have been found in a mere handful of anticlines, many of which were detected by simple "old-fashioned" surface-geology observations. It is to be emphasized that anticlines still account for over 40 per cent of the major fields' oil if the astronomical Middle East reserves are excluded.

It is a moot question whether or not anticlines will be able to maintain their leadership in the years to come. It may well happen that the more advanced exploration techniques now available will eventually shift the balance, and the reserves that will be discovered in the more elusive stratigraphic traps might go beyond the amount now credited to anticlinal traps.

In addition to the Middle East, other anticlinal areas of importance are the California basins, the Central Basin platform of West Texas, the Western Maracaibo basin, and the basins of the Far East (Burna, Sumatra, and Borneo).

Faults far behind . . . It is somewhat surprising that purely fault traps account only for 1.2 per cent of the total oil of the world's major oil fields. The explanation probably lies in the fact that many of the so-called fault traps are really combination traps, the fault being only one of the trapping elements.

Major fault-trap fields are limited to the Gulf Coast and Ardmore basins in North America and to the Orinoco, Magdalena, and Talara basins in South America.

Unconformities lag . . . True unconformity fields again account for a disappointingly low percentage of the total oil found in the major oil fields. Here again, it may be that most of the fields generally considered as unconformity accumulations really belong to the combination type of trap. The leader among the unconformity fields is East Texas field, with over 5 billion barrels ultimate.

An attempt was made to gain reliable information on the amount of oil occurring within 300 ft. of an unconformity. Unfortunately, the figures secured are not conclusive as data on the oil located within 300 ft. of an unconformity were not available for many fields. The incomplete information at hand on 130 fields indicates that 23.5 billion barrels are found within 300 ft. of an unconformity. The amount, 10.8 per cent of the total, is surprisingly low and could no doubt be raised to at least 30 billion barrels should more information become available. This shows the importance of unconformities as places near which sizable oil reserves are likely to occur.

Reefs . . . Reef fields hold 2.4 per cent of the oil of major fields. The three more important areas producing from purely reef traps are the Devonian fields of the Alberta basin of Canada, the Permian and Pennsylvanian reefs

of West Texas and New Mexico, and the Golden Lane fields of Mexico.

Other strat traps . . . Other stratigraphic traps such as pinchouts, shaleouts, asphalt seals, etc., are responsible for 7.3 per cent of the 217 billion barrels of ultimate oil from the free world's major oil fields. The most important fields of this type are located in the Alberta basin, San Joaquin Valley, McAlester basin, Midland and Delaware basins, and the Maracaibo and Orinoco basins.

Combination traps important . . . Combination traps in which two or more trapping elements combine to form an effective barrier contain 6.3 per cent of the total reserves of the free world's major oil fields. Three major areas are responsible for over half of the reserves held in this type of trap. These areas in order of importance are: the Maracaibo basin, the San Joaquin Valley, and the fields associated with the Nemaha ridge of Kansas and Oklahoma.

Lithology of Reservoir

The free-world picture from the standpoint of lithology of the reservoir rocks is shown on Fig. 5. These data are judged particularly significant in that they disprove the commonly held belief that most of the oil found to date is reservoired in limestone and dolomites.

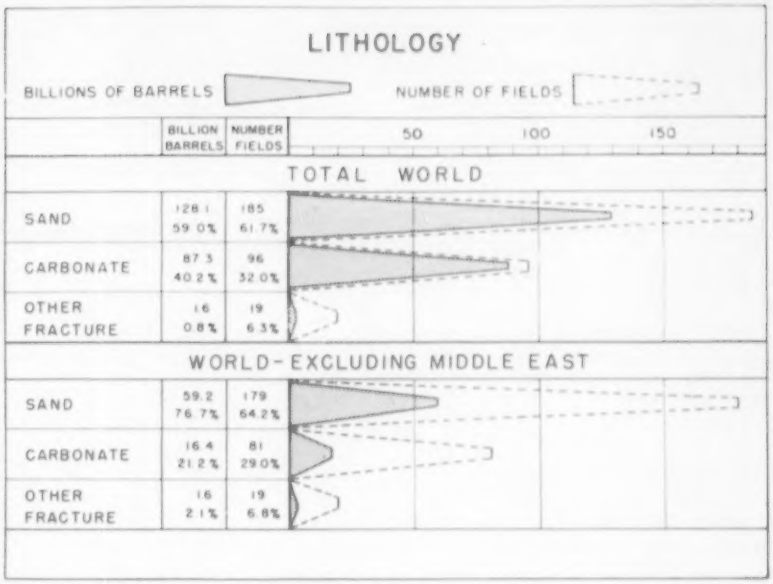
The results presented here show that sand reservoirs hold 59 per cent of the oil found in major fields with carbonates holding almost the entire remaining 41 per cent. Other fractured rocks such as shales and igneous or metamorphic rocks contain only 0.8 per cent of the oil in major fields.

Major fields with sand reservoirs are found in all but 2 of the 42 basins of this study, the exception being the Williston basin and the Cincinnati arch.

Carbonate production from major fields is found in 20 of the basins. Basins having over 1 billion barrels reserves from major carbonate fields are listed below in order of importance: Persian Gulf, West Texas, Northeast Mexico, Alberta, and Maracaibo.

Geologic Age of Reservoir

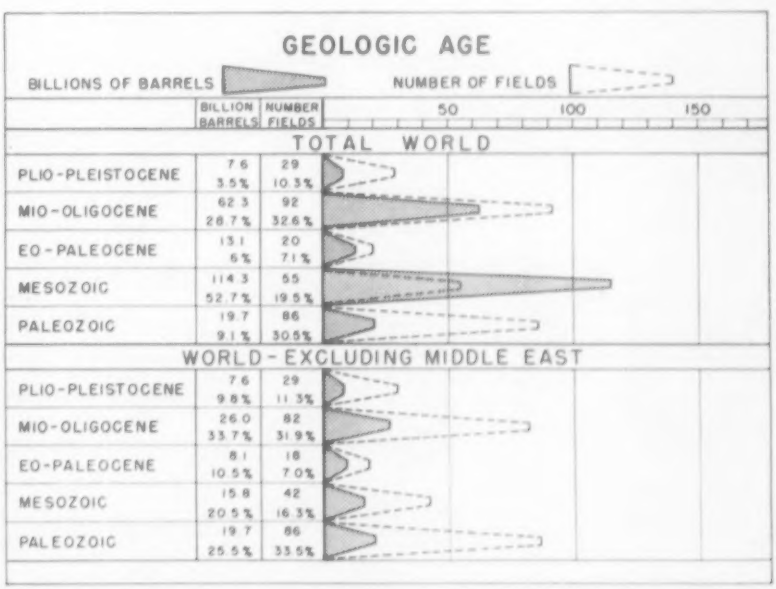
The reserves breakdown according to the age of the producing formation is presented in Fig. 6. The figures clearly indicate the predominant position of Mesozoic and Miocene-Oligocene rocks as oil producers. Sediments belonging to these ages account together for over 80 per cent of the total oil of the free world's major oil fields. Excluding the Middle East, the Miocene-Oligocene becomes the leader trailed by the Paleozoic and Mesozoic, with the Eocene-Paleocene and Pliocene-Pleistocene being virtually tied at the fourth place.



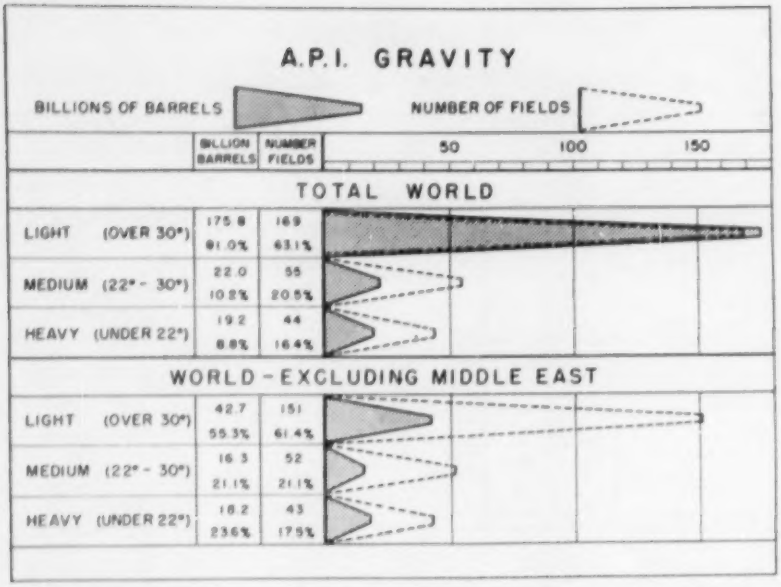
PRINCIPAL RESERVOIR ROCKS are standstones and carbonates; major fields with sand reservoirs were present in 40 out of the 42 basins studied. Fig. 5.

Cenozoic second in importance . . . Major Pliocene-Pleistocene fields are restricted to California, the Gulf Coast, eastern Venezuela, and one field in the Far East. Miocene-Oligocene major fields are present in all the above areas, plus the Middle East, western Venezuela, and Colombia. Eocene-Paleocene fields are more restricted in occurrence, the more important accummulations being located in the Maracaibo basin, Middle East, Magdalena and Talara basins of Colombia and Peru, and the San Joaquin Valley and Gulf Coast of the United States.

Mesozoic No. 1 . . . Mesozoic major fields are concentrated in the Middle East, Rocky Mountain province, Upper Gulf Coast, Mexico, western Venezuela, and Argentina. Out of the 114 billion barrels of Mesozoic oil in the major fields, 98 billion, or 86 per cent,



WORLD FIGURES show that Mesozoic and Miocene-Oligocene rocks are the principal reservoir rocks; however, the lower figure emphasizes the importance of Paleozoic rocks. Fig. 6.



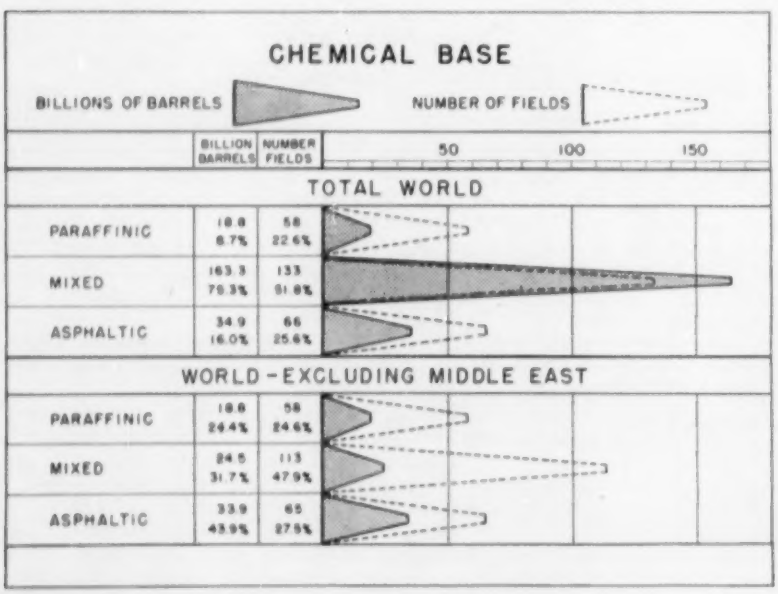
MOST MAJOR FIELDS produce light-gravity oils. Only four basins had no major fields with light-gravity oil. Fig. 7.

occurs in the Middle East producing countries.

Paleozoic trails . . . Paleozoic production from major fields comes almost exclusively from the United States and Canada. The seven most prolific areas having ultimates surpassing 1 billion barrels, in their order of importance, are: Central Basin platform and Midland and Delaware basins of West Texas, Alberta basin, the Nemaha ridge of Kansas and Oklahoma, the Seminole uplift and Ardmore basin of Oklahoma, and the Eastern Interior basin of Illinois, Indiana, and Kentucky.

Mesozoic fields richest . . . A general idea about the relative richness of the individual fields of the various age groups considered can be gained by comparing percentagewise the number of fields and the corresponding reserves of each particular age. For the world as a whole, the picture is as follows: Mesozoic fields lead with 19.5 per cent of the total fields accounting for an overwhelming 52.7 per cent of the total reserves. The Tertiary fields with 50 per cent of the total are responsible for 38.2 per cent of the total reserves. Paleozoic fields, although accounting for 30.5 per cent of the total number of fields, carry only 9.1 per cent of the total reserves.

If the sizable Middle East fields are excluded, the Mesozoic fields still maintain the lead with 16.3 per cent of the fields carrying 20.5 per cent of the reserves; the Tertiary fields greatly improve their position now with 50.2 per cent of the fields being credited with 54 per cent of the reserves; the Paleozoic fields show some improvement with 33.5 per cent of the fields carrying 25.5 per cent of the total reserves. The above comparisons conclusively show that world wide, on an average individual-field basis, Mesozoic major fields are richer than either Paleozoic or Tertiary fields.



THE LARGE MIDDLE EAST reserves account for the preponderance of mixed crudes. The largest asphaltic reserves are located in the Maracaibo basin. Fig. 8.

Habitat of Oil

A.P.I. Gravity

As shown by the data on Fig. 7, light oil predominates over medium and heavy reserves by a substantial margin. It should be emphasized that 91.2 per cent of the total oil discovered in the world's major oil fields is lighter than 22° A.P.I. gravity.

Of interest is the fact that out of the 42 basins having major oil fields, only 4 (Magdalena, Mississippi Salt Dome, Salinas Valley, and Santa Maria) show no light-oil reserves. Medium-oil major fields are located chiefly in California, Gulf Coast, Venezuela, and Middle East.

Important heavy-oil regions include Venezuela, California, and Mexico. Large reserves of the so-called tar oils were not included in the study inasmuch as these are considered noncommercial at the present time and accurate estimates as to their amount are largely lacking.

Chemical Base

The marked preponderance of mixed crudes shown on Fig. 8 is due mainly to the Middle East reserves which almost exclusively belong to the mixed-base category. If the Middle East is excluded, the picture changes noticeably with asphaltic crudes leading the way, followed by the mixed and paraffinic oils. The largest asphaltic reserves are located in the Maracaibo basin. The Gulf Coast and West Texas areas hold the largest reserves of paraffin-base oils.

It should be pointed out that the source data available on crude oil base for various areas are limited and the results shown may vary somewhat should more reliable data become available.

Habitat of Oil

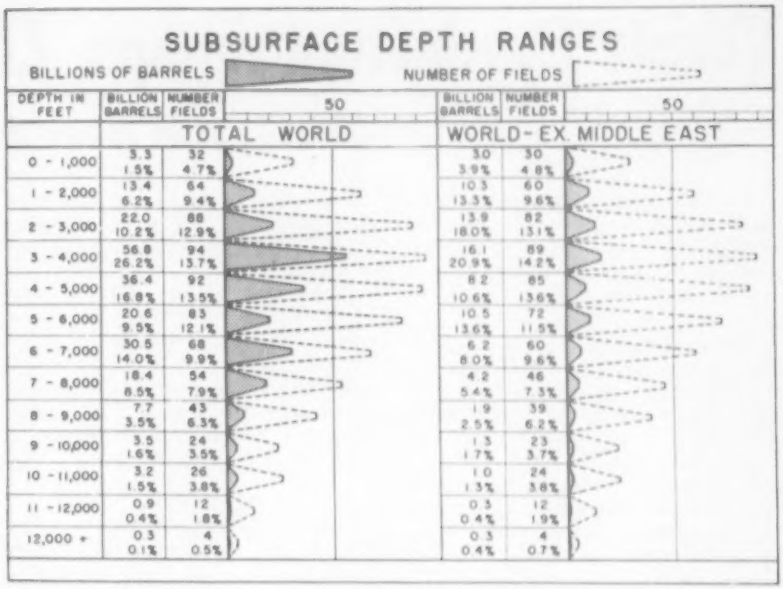
Subsurface Depth of Occurrence

Fig. 9 presents the subsurface depth distribution of oil, by thousand-foot increments, in the free world's major oil fields.

As the tabulation indicates, the richest subsurface depth interval is the 3,000 to 4,000-ft. range which holds 26 per cent of the total oil discovered in the free world's major oil fields. It is noted that from this peak the values decrease in both directions, the decrease being more gradual toward the greater depths.

Of necessity, some of the figures that went into these depth computations must be considered as approximates only, since in some areas the necessary geological details were not available.

It is to be expected that the deeper picture will probably improve with time as more and deeper wildcats are drilled. However, this is the depth habitat of oil as it exists today. **There must be some reason why the bulk of our oil, 85 per cent, occurs at depths between 2,000 and 8,000 ft.** Any answer as to the underlying cause for such distribution would be a contribution toward a better understanding of the processes of oil generation and accumulation.



THE RICHEST subsurface depth interval is the 3,000-4,000-ft. range. The deeper picture will probably improve with time as more and deeper fields are uncovered. Fig. 9.

Time of Discovery

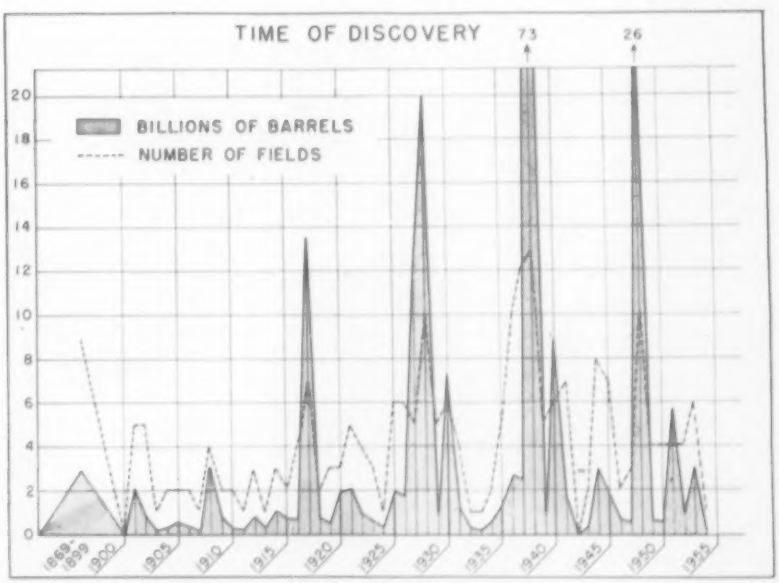
Fig. 10 shows the number of major fields and the amount of oil discovered on a yearly basis since 1900. It is interesting to note the 10-year cycle of major discoveries, beginning with the Bolivar coastal fields of western Venezuela in 1917. The peak discovery year with 73 billion barrels occurred in 1938 with the discovery of Burgan field of Kuwait. Small amounts of oil were discovered during the economic depression of the early thirties following the discovery of East Texas field and again during the relatively inactive period of World War II. The values for the years since 1950 will probably move upward as those new fields become properly evaluated.

Conclusions

Statistics can be dull and quite meaningless unless they carry a message. It is hoped that the statistics presented in this study will at least serve the following purposes:

1. Make petroleum geologists more familiar with the location and distribution of the bulk of the free world's oil.
2. Present an over-all picture of the preferred localization of this oil from as many points of view, geologically or otherwise, as a general study of this kind will permit.
3. Stimulate work and research seeking rational geological explanation for the patterns of distribution shown.

"It is a moot question whether or not anticlines will be able to maintain their leadership in the years to come. It may well happen that the more advanced exploration techniques now available will eventually shift the balance, and the reserves that will be discovered in the more elusive stratigraphic traps might go beyond the amount now credited to anticlinal traps."



DISCOVERIES OF MAJOR FIELDS seem to follow a 10-year cycle. Peak year was 1938 when Burgan field in Kuwait was uncovered with its 73 billion barrels of oil. Fig. 10.

Illinois Production Jumps 21 Per Cent...

with credit going to new drilling and to water flooding

ILLINOIS oil production jumped from 67 million barrels in 1954 to 81 million barrels in 1955, a 21 per cent increase. At the same time the number of wells drilled increased by 19 per cent.

Illinois produced more oil in 1955 than in any year since 1943 (Fig. 1). It was the second year of increases which have reversed a 13-year downward trend.

Of the 14-million-barrel increase, some 6 million barrels is to be credited to water-flooding, the rest to increased drilling and the wide use of hydraulic fracture treatment in completing wells.

Sands Shallow, Costs Low

Illinois has been called a paradise for the small or independent oil operator, largely because pay sands are many and shallow, so that drilling costs are low.

Pay sands have been found at depths that range from 150 ft., in the old Warrenton-Borton area, to 4,600 ft. in the Trenton at Salem. Compare such depths to a range of 7,000 to 10,000 ft. in the Gulf Coast region.

The cost of completing a well averages only about $25,000 in Illinois. Double, triple, or quadruple the cost for wells of greater depth elsewhere.

This article was prepared for The Oil and Gas Journal by the Illinois State Geological Survey, Urbana, Ill.

Many minor stratigraphic traps have given Illinois a fairly broad scattering of many small pools within the Illinois basin proper.

In 1955, a total of 120 successful wildcat wells opened 35 new pools and extended productive acreage at 85 locations. Out of the wildcats drilled within 2 miles of production, 1 in 5 was a producer; out of those drilled more than 2 miles from production, 1 in 19 was a producer.

Highlights

Illinois is the largest oil producer east of the Mississippi, ranks eighth among oil-producing states. Production rate in Illinois is now about 230,000 bbl. a day.

Moneywise, last year's yield of 81 million barrels (bringing an average field price of $2.91 per barrel) amounted to more than 238 million dollars.

Secondary-recovery methods accounted for 30 per cent of the 1955 oil production. All methods, which squeeze additional recoverable oil from the reservoirs will be of increasing importance to the oil economy.

Consumption rate of refined products in Illinois—gasoline, lubricants, fuel oil etc.,—is estimated to be the equivalent of 337,000 bbl. of crude oil per day. Production is therefore, about two-thirds of consumption at the present rates.

Soon after Drake drilled his famous well at Titusville, Pa., in 1859, early wildcatters began testing for oil in Clark County, Illinois. Probably because the drillers were not able to shut off the water, not one of the dozen or so holes was completed as a producer. Another 40 years passed before eastern Illinois produced oil.

Over in western Illinois, however, a coal miner in Montgomery County noted that crude oil collected in the sump at the bottom of a mine shaft. The clue led to drilling a shallow gas well near Litchfield in 1882. A few years later additional drilling discovered oil. The oil, which sold for 8 to 10 cents a gallon, was used as lubricating oil by factories in the neighborhood.

Litchfield pool was the only source of Illinois oil production through 1903, according to statistics published by the U. S. Bureau of Mines. One of the first oil wells drilled is still open and occasionally a little oil is bailed out.

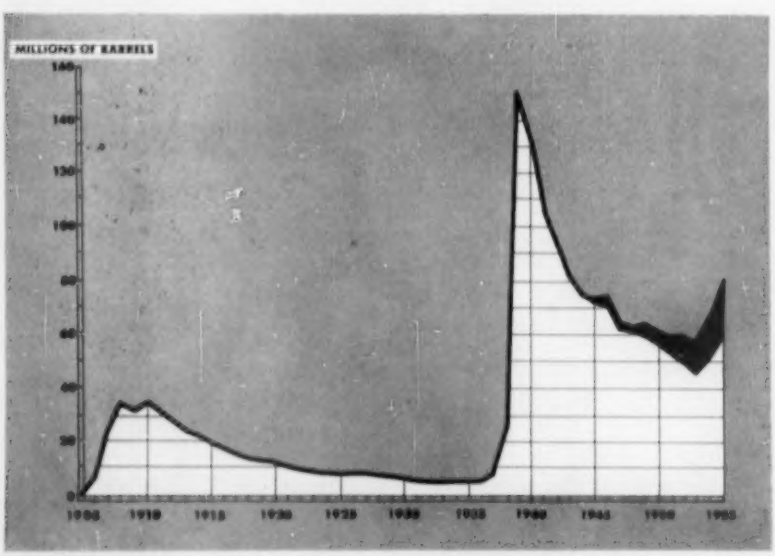
In 1904 renewed drilling in Clark County opened up the southeastern Illinois oil field in Clark, Crawford, Lawrence, and parts of adjacent counties. The field was drilled up largely between 1905 and 1912, reached its peak production of 33.7 million barrels in 1908, and by 1955 had yielded a grand total of more than half a billion barrels of oil.

The southeastern field has produced more oil than any other field in Illinois. In recent years renewed drilling in Clark, Crawford and Lawrence counties has produced oil from some of the deeper formations in old producing areas but where the new oil zones had not been tested before. In 1955, some 341 producers were completed in the three counties.

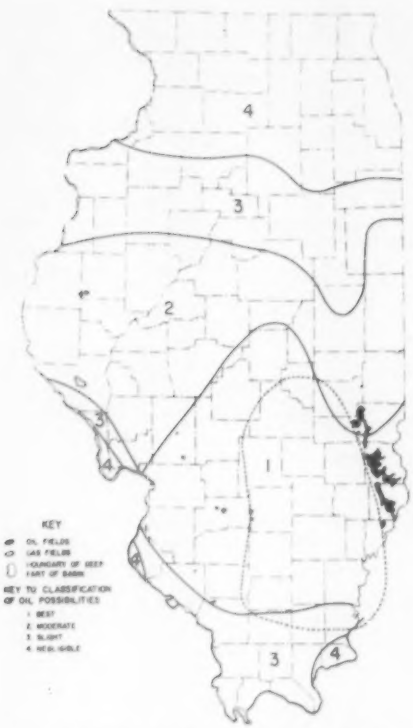
Until 1937 the southeastern fields produced almost 98 per cent of the Illinois oil. The rest of the oil came from scattered small pools in western Illinois, such as Carlyle, Sandoval, Colmar-Plymouth and Dupo. All of the fields were around the margin of the Illinois basin partly because the central deeper part had been considered unfavorable and partly because early oil tests were not drilled deep enough.

Oil in the Illinois Basin

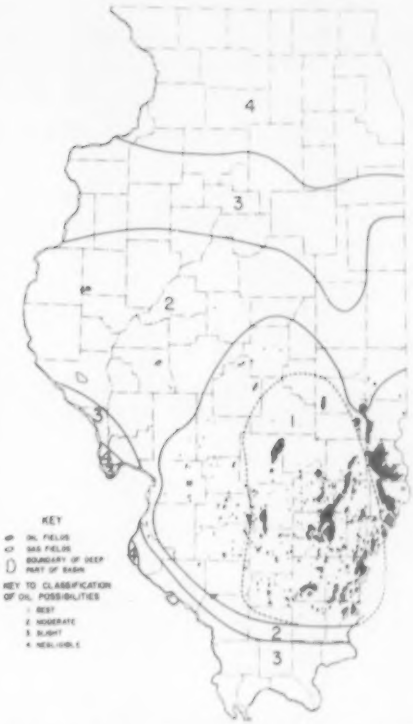
Discovery of oil in small structures within the Michigan basin prompted the geologic study of other structural basins. Alfred H. Bell, who has been head of the Illinois Geological Survey's Oil and Gas Division since 1930, was one of the



ILLINOIS OIL PRODUCTION increased about 14 million barrels in 1955. Of this amount some 6 million barrels may be credited to water flooding (solid area). Fig. 1.



OIL AND GAS possibilities of Illinois classified by areas, 1930. Fig. 2.



OIL AND GAS possibilities of Illinois classified by areas, 1955. Fig. 3.

From Illinois State Geological Survey Ill. Petroleum 72, 1955.

geologists who stressed the importance of geological research in locating oil tests in Illinois prior to discovery of oil in the Illinois basin. In 1930 he prepared a map classifying the area of Illinois according to oil possibilities (Fig. 2). Twenty-five years later, on the basis of subsequent drilling, Dr. Bell revised his map, making only minor changes (Fig. 3).

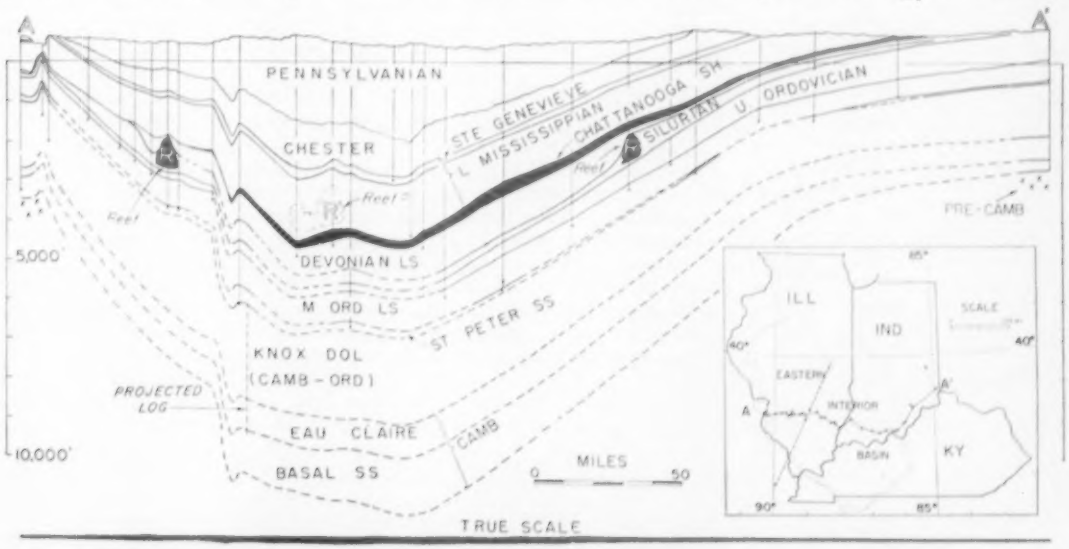
A number of oil companies began independent exploration and leasing early in the 1930's. Pure Oil Co. 1 Weiler in 23-3n-8e, Clay County, completed February 26, 1937, opened Clay City oil field near the central part of the Illinois basin. The well yielded an initial production of 40 bbl. from the Cypress formation in the Chester (Upper Mississippian series) at a depth of 2,608-13 ft.

Less than 3 months later Pure Oil Co. brought in the first big producer, the famous 1 Bunny Travis, near neighbor to the Weiler well. The Travis well came in with an initial production of 2,565 bbl. from McClosky oolitic limestone at depths of 2,950-60 ft. in the Ste. Genevieve formation (Lower Mississippian series).

The big well touched off a frantic activity in the basin area, and drilling has been active ever since. Eight pools were discovered in 1937. The next 3 years brought in 15, 28, and 30 new pools, to make a total of 81 pools by the end of 1940.

By 1940 the new pools skyrocketed Illinois oil production to a peak of 147 million barrels. During the peak year much of the oil came from porous Devonian limestone in Salem and Centralia fields where a number of wells had initial production as high as 8,000 to 12,000 bbl. Devonian production fell rapidly so that in 2 years the total production for the state had decreased almost a third. The following years showed a period of progressive decline to a level of about 6 million barrels a day.

Since 1941, the number of new pools discovered each year has ranged from 24 to 44, with a grand total of 538. Many of the small pools were consolidated as additional drilling extended the proved acreage. Pool extensions, additional discoveries, and the recent expansion of secondary-recovery techniques have again turned the trend upward from a low of 59 million bar-



CROSS-SECTION of Eastern Interior basin. (From Bull. A.A.P.G. Vol. 35, No. 2, Feb. 1951, p. 488). Fig. 4.

rels in 1953 so that in 1955 the yield was 81 million barrels.

Depths to Oil

The first oil produced in Illinois in the Litchfield area came from a lower Pennsylvanian sandstone at a depth of 640 ft. in 1886. Much of the oil from southeastern Illinois also came from shallow Pennsylvanian sandstones that ranged in depth from 225 ft. in the Shallow sand, Martinsville pool, Clark County, to 2,110 ft. at Bone Gap pool in Edwards County.

The first Mississippian oil was produced from the Westfield lime (St. Louis-Salem) in Westfield pool, Clark County, in 1904. Depths to the Westfield lime in the pool average 335 ft. Chester production began in 1907 in Lawrence County from the Kirkwood (Cypress) sand. Depths to the top of the Cypress average 1,400 ft.

The early production came mostly from the LaSalle anticlinal belt, in the east part of the basin. Some 2 per cent of the state's total oil through 1936 came from the small pools on the shelf along the west side of the basin.

Devonian production was discovered in 1925 in Martinsville pool, Clark County, at a depth of about 1,550 ft., but gave its most spectacular production in the Salem and Centralia pools at depths of 2,870 to 3,440 ft. between the years 1939 and 1941.

The first known Silurian oil was discovered in Marine pool, Madison County, in 1943, at an average depth of 1,740 ft. Ordovician oil was first produced in 1910 from the Westfield pool in Clark County from a depth of 2,300 ft.

The 45-50 oil-bearing zones in Illinois include sandstones and porous limestones of Upper Mississippian, Lower Mississippian, Devonian, Silurian, and Ordovician age.

The Mississippian rocks account for about three-fourths of the oil produced in Illinois. The major Pennsylvanian production, from the old fields of southern Illinois, has yielded about 20 per cent of the grand total production to date. The remaining 5 per cent of the oil has come from rocks of Devonian, Silurian, and Ordovician ages.

Types of Reservoirs

Essentially all of the reservoir rocks in Illinois are limestones or sandstones. Some pools are on structures, such as domes (the Salem, for example) and anticlines (as Clay City). Others are in faulted areas, and still others depend on variation in porosity along anticlinal trends, such as the McClosky production in Clay City Consolidated pool. Some pools depend on the porosity and permeability of the material in the original deposit, such as old coral reefs or sand bars, for example, the Marine pool reef structure and the sand lens in the Waltersburg formation in the Eldorado pool. The Eldorado pool has produced 4 million barrels of oil within less than 2 years.

Some of the pools occupied stratigraphic traps on the west flank of the LaSalle anticline.

Aids to Production and Secondary Recovery

Standard treatment for finishing a producing well used to be shooting with nitroglycerin. In 1935 Illinois operators began acidizing wells. A few years ago hydraulic fracture was introduced. Hydraulic-fracture techniques were used on about 70 per cent of the producing wells completed in 1954 and a slightly higher percentage were so treated in 1955.

It is never possible to get all of the oil out of a reservoir. One of the early pioneers in methods that might increase the amount of recoverable oil was Frederick Squires, former petroleum engineer at the Illinois State Geological Survey. His first work on the problem was done at Marietta, Ohio, where as a private oil operator he was granted his first patent on an apparatus and method of recovery of oil and gas. He sought to repressure a depleted oil field by injecting air or natural gas and thus induce flow of oil to the producing wells.

Later Dr. Squires joined the Illinois Geological Survey staff where he did extensive work in secondary-recovery techniques and published many reports.

The use of water flooding, the favorite method in Illinois oil fields, promises to yield an additional billion barrels of oil which would not have been available by the older methods of oil production. The number of installations has doubled in the last 2 years, bringing the total to some 300.

Water floods are now in use on less than 20 per cent of the proved acreage in Illinois, yet they were responsible for some 30 per cent of the state's total oil production in 1955.

Use of secondary-recovery methods is increasing both the life and the total yield of oil from Illinois fields. The latest refinement in techniques of secondary recovery involves the use of heat.

Illinois has 19 pipelines that carry crude oil and 9 that carry products.

Several pipelines bring oil from other states into or across Illinois. The state has two underground storage reservoirs for natural gas, both in porous sandstone, one at Waterloo and one at Herscher. Four mined caverns for storing liquid propane are at Eola, Kankakee, Tuscola, and Crossville. Illinois has 17 refineries which all together can treat a total of 527,500 bbl. of crude oil each day.

In Illinois nearly all of the natural gas which comes out of solution from the oil when the oil comes to the surface and pressure is released. Total natural gas produced in 1954 is estimated at 20 billion cubic feet.

In the past gas has been marketed from a number of gas pools, but in 1955 the only gas marketed for use away from producing areas was from the Harrisburg and Herald Consolidated pools, both in the White-Gallatin-Saline counties area. The total gas amounted to about 175 million cubic feet in 1954, which had an estimated value (at the wells) of $17,500.

Developments in 1955

In 1955 total drilling was up about 75 per cent from that of 1953, and the uptrend is continuing into 1956. Interesting new developments at the end of 1955 were the Oak Point area in Clark County, Cooks Mills in Coles County, and Kincaid South in Christian County.

Oak Point pool is an Aux Vases field on the west flank of the LaSalle anticline 2 miles from nearest production.

Cooks Mills pool produces Rosiclare and Aux Vases oil and Cypress gas on a structural high at the north end of the Illinois basin.

Kincaid South is part of the recent development along the northernmost part of the basin. It produces from Devonian limestone.

Future Outlook

With the upsurge of demand for oil, increased Illinois production, and because Illinois is handy to large markets, oil operators will continue their intensive search for oil in Illinois.

It is only logical to continue to drill deeper in known producing fields in order to test lower possible pay zones.

Many refinements will come into use as guides to finding an adequate supply of oil to fuel and lubricate the machines of today and those postulated for tomorrow. Stratigraphers and micropaleontologists will have to use all they can learn in both field and laboratory to interpret correctly the ecology of the oil deposits and arrive at the best possible location for oil tests.

New refinements will necessarily follow current research on variations of facies within formations so that prospectors for oil can locate and test the natural stratigraphic traps within formations.

It is quite possible that during the next 50 years Illinois will produce as much oil as has been found in the past.

. . . finding OIL with GEOPHYSICS

Joe is a satisfied oil man, because he is successful in finding new oil fields. His record over the years has been running about 20 per cent on new-field wildcats compared to a national average of about 12 per cent. We had heard about Joe's record and knew his background. He is a small independent. You can find men exactly like him in Denver, Midland, Houston or Tulsa — in short he is a typical oil man in many respects. The only difference is that he finds new oil fields, year in and year out.

The Journal interviewed the various successful Joes around the country, asking them why they were successful. And to a man, they attributed their success to carefully planned exploration work with geophysics playing a major role.

But one of the big objections to geophysical work is the cost. Joe had a ready answer for that and showed us why he used geophysics. Joe claims that he can process 50 leads for 2 million dollars with the aid of geophysics and find 5 new oil fields. Without geophysics it will cost him $800,000 more to uncover the same number of new oil fields. "That's why I use geophysics," Joe said. "It's just smart business. I can find the same number of oil fields using geophysics and spend 40 per cent less money."

it's just smart business!

check the record

EXPLORATION AND DRILLING COSTS TO PROCESS SUBSURFACE PROSPECTS

	With geophysics	Without geophysics
No. of leads processed	50	40
Cost of geophysics at $5,000 per lead	$250,000	—
Leasing cost at $10,000 per acceptable lead	$250,000*	$400,000
Cost of testing pay zone at 6,000 ft. (does not include running casing, etc.), $60,000 per well	$1,500,000	$2,400,000
Total cost of exploration	$2,000,000	$2,800,000
Anticipated number of new fields	5	5
Average cost per new field	400,000	$560,000

*Joe estimates that geophysics will condemn 50 per cent of the subsurface leads.

The Journal then checked into the problem of oil finding in the various parts of the country and found that geophysics is extremely useful in uncovering most of the important oil traps, either directly or indirectly.

In using geophysics, one of the very first steps is to know the kind of oil traps you may expect to find. These traps, of course, are quite different in the various oil provinces of the country. Along the Gulf Coast the principal traps are related to salt movement; in West Texas the emphasis is placed on finding reefs and deep-seated anticlines.

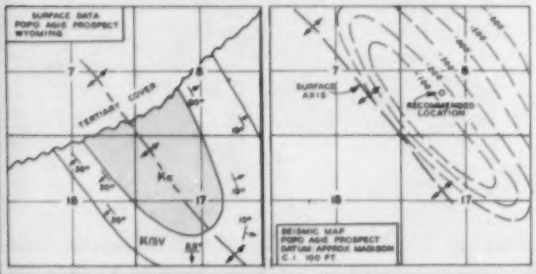
Here the Journal gives you the important oil traps for the hottest oil provinces — 4 in the United States, and West Canada. The chart lists the diagnostic geologic and seismic features and explains how geophysics can be used to map each type of trap. Of course, this is only a summary of the more important oil traps for each area. The successful oil finder is always on the lookout for a new type of trap whether he is working on the Gulf Coast or in Canada.

Consider all the following factors

ROCKY MOUNTAINS

MAIN TARGETS

ASYMMETRICAL ANTICLINES



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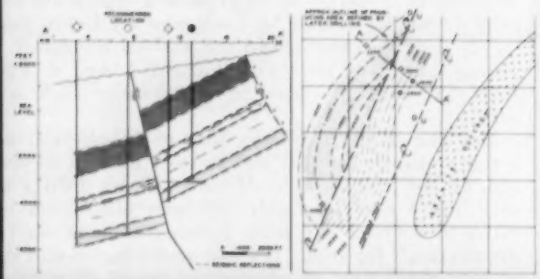
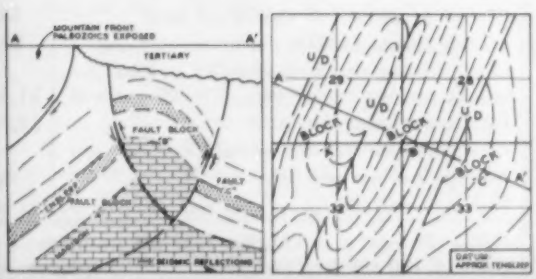
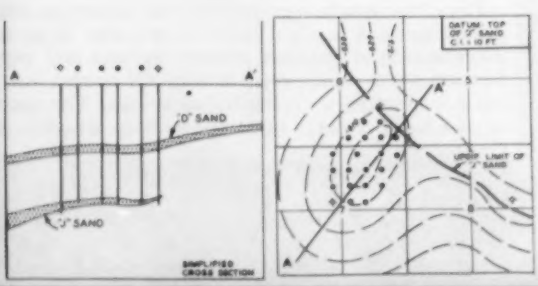


OVERTHRUST FOLDS



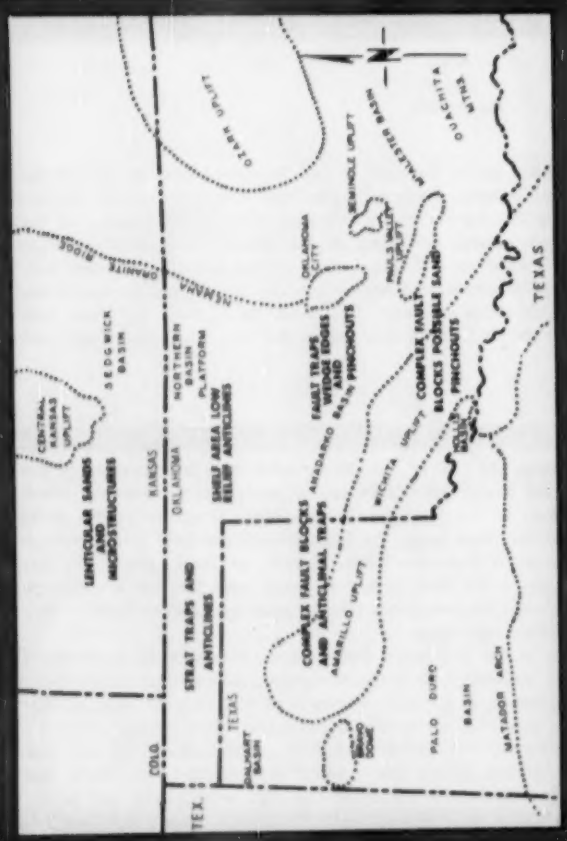
STRAT TRAPS



SEISMIC FEATURES	DISCUSSION
☐ Beds usually steeply dipping on one flank. ☐ Occur in trends, and related to major uplifts. ☐ May be obscured by Tertiary beds. Shoot perpendicular to regional trends.	Surface geology has played a dominating role in the Rocky Mountains since most of the large structures are evident as surface structures. In recent years oil companies have begun to rely more heavily on geophysics to find new oil fields. Teritiary noses can become low relief anticlines at Tensleep level, and combining photogeology with seismic surveys has rewarded many Rocky Mountain operators. Geophysics is extremely useful in locating the crest of the deeper structure, for experience has shown that the crest of the deeper lead may not underlie the surface structure. Of course, many simple anticlines produce oil in the Rockies. Rocky Mountain structures are related to the regional features and frequently occur in trends or in a series of en echelon folds. Since the structures can have considerable relief, it is best to lay out a well-designed field program. Continuous profiling coupled with four-way spreads may be necessary to determine dip in the more complex area. Shooting at right angles to the strike frequently will improve the record quality.
☐ Often associated with thrusting. ☐ Dip shooting very effective if coupled with continuous profiling. ☐ Plot geologic data on the seismic sections before analyzing.	To date there has not been a large amount of oil produced from faulted noses in the Rockies. This type of trap may increase in importance, but there is the problem of time of accumulation. Did the faulting occur early enough to trap the oil? If the answer is "yes," then faulted traps will make attractive prospects. Locally, at least, the faulting serves to trap the oil and this has stimulated interest in faulted noses. Probably the long-range exploration program now under way in the Disturbed Belt of Montana will find many of these traps. Geophysics works well in mapping this type of structure. And in the Rocky Mountains, the seismic surveys can often be tied to surface outcrops where well control is lacking. The usual procedure is to locate a surface lead and then check it with seismic work. If the shooting confirms the surface work, a well is staked.
☐ Seismic data difficult to interpret. ☐ Combine surface geology, subsurface, and seismic data. ☐ Shoot perpendicular to regional or local trends. ☐ Refraction shooting has proved effective.	Rocky Mountain operators look to the Disturbed Belt as one of the last exploration frontiers. Both reflection and refraction seismic surveys are used to map the regions where thrusting is suspected. Because of the complex geology, careful designing of the seismic program is essential to insure usable field data. Continuous profiling and dip shooting provides valuable information, and seismic sections are the key to unraveling the complex subsurface geology. But even these must be used with caution because thrust faulting may repeat the same formation three and four times.
☐ Extremely difficult to map with seismic. ☐ Subsurface control essential. ☐ Accurate velocity control a must. ☐ Occur on flanks of regional and local uplifts.	More and more, the role of the stratigraphic trap is increasing in importance, and the Rocky Mountains are no exception to this rule. Much of the production in the Denver-Julesburg basin is controlled by facies changes. In the San Juan basin, the huge Blanco gas field is a strat trap that covers about 1.2 million acres. Locally at least, geophysics has proved successful in the Rockies for mapping sand pinchouts, although at the moment many oil companies rely on strat tests and subsurface data entirely for finding strat traps. The majority of the D-J basin fields are evident as noses or terraces with production controlled by both stratigraphy and structure. However, the structural closure, if present, is measured in terms of tens of feet and more often than not, no structural closure can be mapped. Geologists point to the excellent strat-trap possibilities on the east side of the Williston basin, but finding wedge-edge production has proved an onerous task. The relatively flat dips both above and below the unconformity pose a problem that the geophysicist has yet to master.

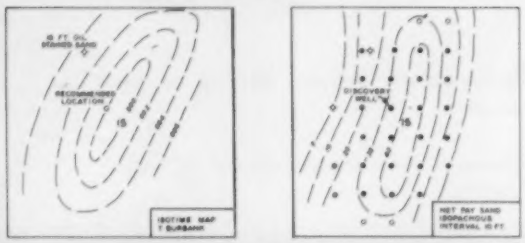
MID-CONTINENT

The Mid-Continent continues to be a fertile hunting ground for both geologist and geophysicist. The search ranges from the complex fault trends in southern Oklahoma to the Cambridge arch in western Kansas. Even today, geophysics is uncovering new fields with 1,000 ft. of producing closure. At the other extreme are the tilted noses in North-Central Oklahoma where Wilcox sands produce from anticlinal noses that show little or no closure. And geophysics is of definite value in mapping the stratigraphic plays, particularly where truncated wedge edges are the primary target.

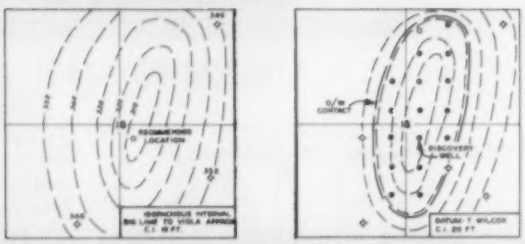


MAIN TARGETS

LENTICULAR SANDS



MICROSTRUCTURES



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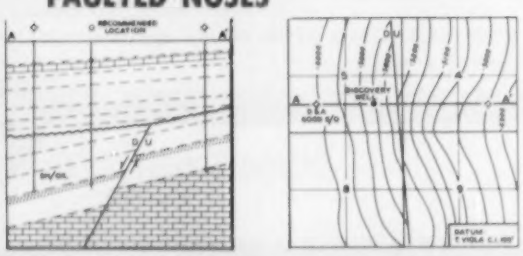
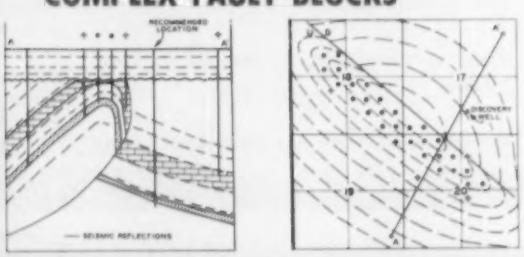
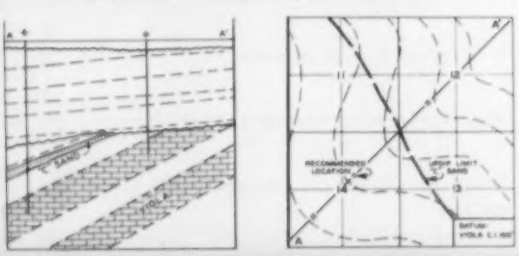


COMPLEX FAULT BLOCKS



TRUNCATED WEDGE EDGES



- ☐ Often found in areas of divergence.
- ☐ Isopachous maps help pinpoint prospect.
- ☐ May occur in trends.
- ☐ May occur on flanks of large structures.

Many Mid-Continent geologists are concentrating their efforts on mapping lenticular Pennsylvanian sands. Geophysics faces a real problem in this field, but several methods hold promise for pinning down these strat traps. Theoretically, the oil-bearing sand lenses have a lower velocity than the surrounding shales. As a result, the lenses are evident as "thicks" if the interval in which the sand occurs is mapped.

In northern Oklahoma and southern Kansas, for example, mapping the interval between the top of the Big Lime and a pre-Pennsylvanian marker can indicate areas where the Bartlesville, Burbank, or Red Fork sand will develop. Isotime or isopachous maps are essential for mapping stratigraphic traps.

- ☐ Small in areal extent (320 acres or less).
- ☐ Often less than 50 ft. of closure.
- ☐ Appear as isotime or isopachous thins.
- ☐ May be weakly reflected in overlying beds.
- ☐ Map horizon near pay zone.

Low-relief structures that cover only 160-320 producing acres make a very attractive target for the bit. Wilcox fields in this category have yielded as much as 25,000 bbl. per acre. Careful, detailed seismic work can map these pimples, particularly if the new high-frequency high-resolution recording units are used. These highs are usually not reflected in the overlying Pennsylvanian beds, but will appear as a "thin" when mapping the interval from the top of the Mississippian to the top of the Wilcox. Since the thinning or structural relief is about 50 ft. or less, extreme care is needed to map these leads. Isopachous maps furnish a paleostructural picture that shows how closed structures become oil-bearing noses through later regional tilting.

- ☐ Usually occur in trends.
- ☐ Requires detailed shooting.
- ☐ Closed loop shooting maps faults.
- ☐ Faulting may not affect younger beds.

Along the edge of the major uplifts, fault trends are present that form small but prolific oil fields. Although these fields are closely related to the regional structure, detailed seismic work is essential to find both the faulting and the closure. Generally speaking, the faults are the normal or gravity type, and more often than not, production is found on the downthrown or basinward side.

Adequate well control and closed-loop shooting are the best solutions for mapping these fault closures. More often than not, the faults will not affect the younger Pennsylvanian beds and may be evident only in the lower Pennsylvanian and pre-Pennsylvanian beds. Thus it is essential to map a reliable marker close to the Simpson pay zones.

- ☐ Usually occur in long narrow trends.
- ☐ Migrate reflections if necessary.
- ☐ Shoot 4-way spreads for dip data.
- ☐ Analyze seismic cross sections carefully.
- ☐ Plot well control on seismic section.

"Mountain-front" geology is not confined to the Rocky Mountains. Southern Oklahoma and parts of North Texas have their share of complexly folded and even thrust-faulted oil traps. Shooting in these areas requires careful planning and properly designed field work to assure best results. Interpretation requires a sound knowledge of both regional and local geology and a thorough background in geophysics.

Many companies have turned to continuous-line dip shooting in the complex thrust-faulted areas.

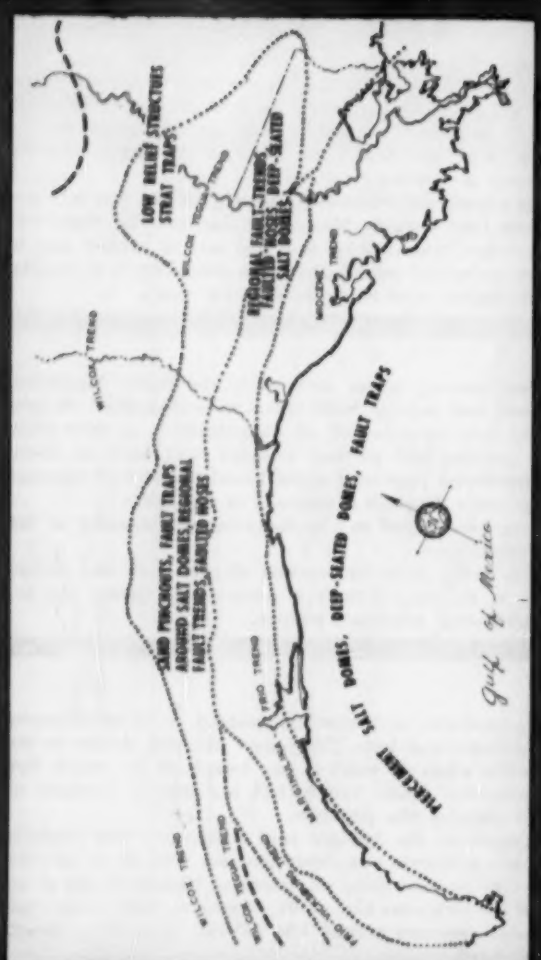
Interpretation is made easier by working directly with the seismic sections. Because of the steep dips, it is neecssary to migrate the reflections into their correct subsurface position.

- ☐ Coordinate subsurface and seismic data.
- ☐ Map horizons above and below the trapping unconformity.
- ☐ Usually occur on flanks of large uplifts.

The producing sandstone or limestone is trapped at an unconformity by the overlying impervious beds. These traps are very similar to the pinchouts, but wedge edges are easier to map because of the steeper dips below the unconformity. Again, well control is absolutely necessary to insure success in mapping the pinchouts.

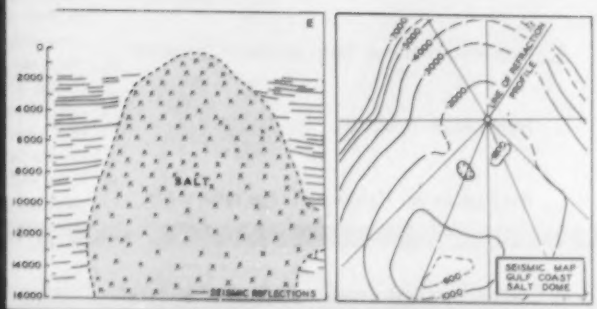
In southern Oklahoma, the Springer sand is truncated and produces along a narrow belt in Garvin and Grady counties; West Short Junction near Oklahoma City produces from the truncated Hunton limestone on the west flank of the Oklahoma City uplift. In general, these wedge-edge traps cover a large area and present few difficult gological problems once they are discovered.

GULF COAST



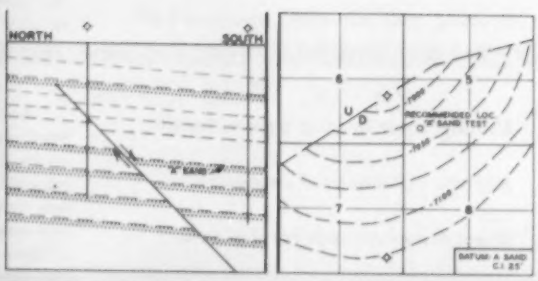
MAIN TARGETS

SALT DOMES

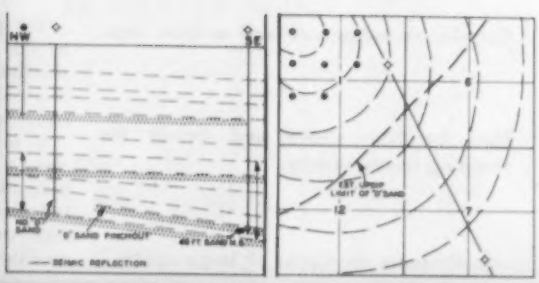


DEEP-SEATED SALT DOMES

FAULT TRAPS



UPDIP SAND PINCHOUTS



SEISMIC FEATURES — DISCUSSION

- ☐ Evident as a gravity anomaly but may be masked by large regional features.
- ☐ Salt occurs at shallow depths.
- ☐ Innumerable possibilities for new oil on faulted flanks.
- ☐ Beds near salt core dip steeply.
- ☐ Detailed shooting best approach in mapping salt domes.

Nearly all Gulf Coast structural traps are related to salt movement. The most obvious are the piercement-type salt domes where the salt is found at relatively shallow depths. Gravity surveys provided a reliable method of mapping salt domes along the Gulf Coast during the early days of geophysics, and even today the gravity method is a reliable exploration tool. But the reflection seismograph through the years has proved its effectiveness in defining the domes and in helping to unravel the complex faulting common to salt domes.

Closed-loop shooting is desirable and, of course, all wells on or near the prospect must be tied. This helps to eliminate possible velocity errors or errors in record picking.

Production on the domes can occur below bulges in the salt plug or overhangs. Special geophysical well surveys map the outline of the salt and help to show the oil traps formed by the overhang. Negative evidence such as lack of reflections is another clue to the presence of salt.

- ☐ Typical fault pattern, graben over crest of structure.
- ☐ May be evident as a gravity anomaly.
- ☐ Salt-ridge fields can occur in trends.
- ☐ Both faulting and closure are hard to detect.
- ☐ Use detailed shooting with closed loops.

This type of oil trap contains the cream of Gulf Coast production. Actually they are similar to the shallower salt domes in that they are formed by salt movement. However, the salt is seldom cut by the wells.

Deep-seated salt domes have a typical fault pattern with a central graben bounded on each side by one or more normal faults. Oil can accumulate in any of the fault traps formed, or in the central graben.

The reflection seismic method has found many of these structures. But many more will be uncovered with improved instruments and field methods and better interpretation and subsurface control. Offshore, these structures will account for a substantial amount of the future production because many of these deep-seated domes have already been mapped. Detailed shooting and coordination between geology and geophysics provide the answer to mapping deep-seated domes.

- ☐ "Down-to-the-coast" faults often control production.
- ☐ Throw on fault may be less than 100 ft.
- ☐ Occur in trends.
- ☐ Detailed closed-loop shooting maps lead.

Along the Gulf Coast, there are many faulted noses that produce. The faults roughly parallel the regional strike and the oil is trapped either on the coastal side or the landward side of the fault. There often is turnover into the fault and the structure becomes an elongate low-relief anticline.

Production is controlled by normal faults, and the displacement across the faults can be less than 100 ft. For this reason, these fault traps are difficult to map, but careful record interpretation uncovers even this type of fault. Detailed shooting with closed loops is the answer to locating faulted traps on the Gulf Coast. "Trendology" plays a role in exploring since the faults may be regional rather than local; production occurs along the fault trend where structural conditions are favorable.

- ☐ Sand pinches out updip.
- ☐ Tie seismic survey to wells.
- ☐ Likely to occur in areas of abnormal thinning.

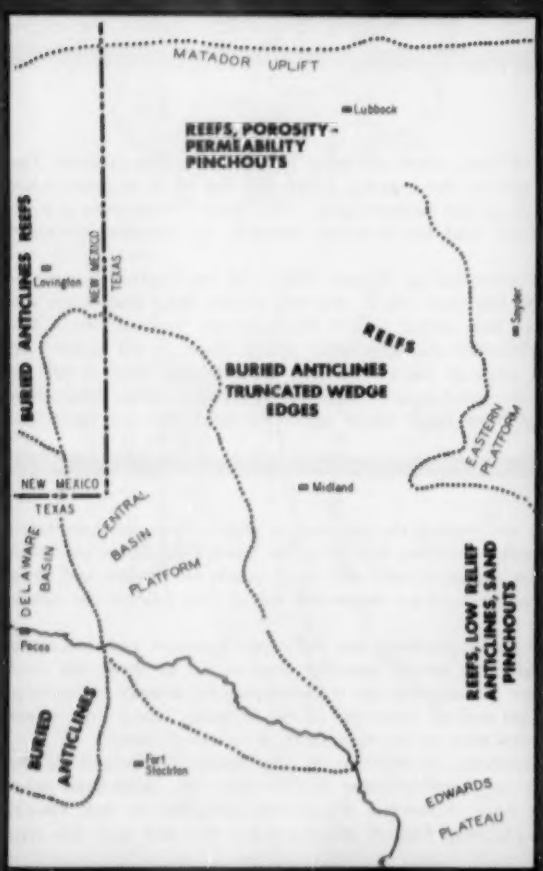
Louisiana has not reached the exploration phase where sand pinchouts dominate exploration thinking. But along the Texas Gulf Coast, pinchouts are an important source of new oil. Sands pinch out updip, and these can be of regional importance where old strand lines control the pinchout.

Although the updip pinchouts are the most important and numerous, there are several fields where downdip traps occur. In these, the sand wedges out where the regional dip is interrupted by doming or faulting. Frio sands are gas and oil reservoirs in the Mustang Island area where they pinch out downdip on the west flank of known structures.

Gulf Coast pinchouts are difficult to map seismically because of the nearly flat dips and rapid changes in lithology, but isopachous maps have proved of value. Subsurface control has provided the best answer to date, but geophysicists look to the day when they can map this type of trap.

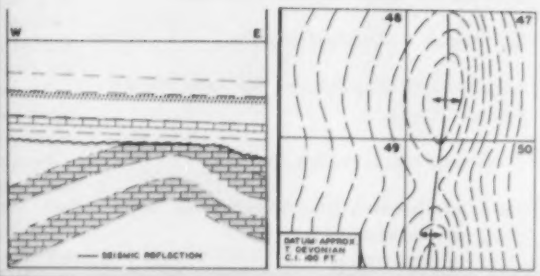
WEST TEXAS

Exploration in West Texas continues to expand due in part to recent geophysical shooting techniques. The trend is toward deeper drilling and geophysicists have turned to pattern shooting and multiple geophones to outline the deep Ellenburger and Devonian producing trends. The new fields are related to the major structural features of West Texas: the Midland and Delaware basins and the Central Basin Platform. Structural traps and reefs assume major importance on the eastern shelf of the Midland basin.

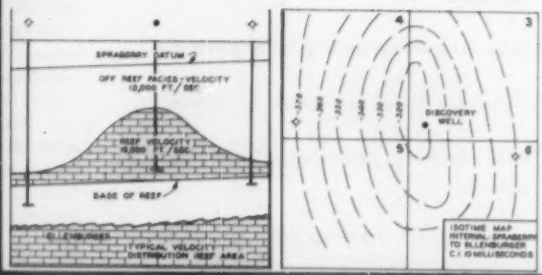


MAIN TARGETS

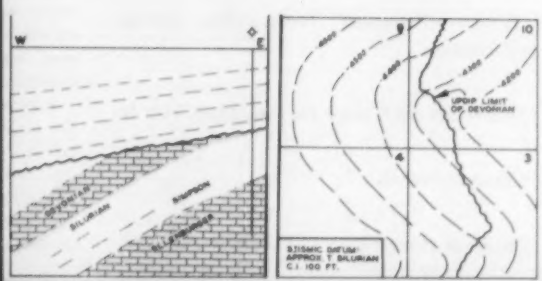
BURIED ANTICLINES



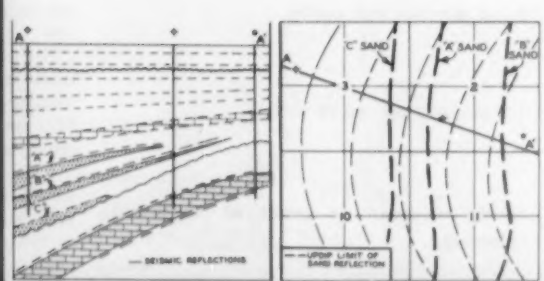
REEFS



TRUNCATED WEDGE EDGES



UPDIP SAND PINCHOUT



SEISMIC FEATURES

- ☐ Ellenburger highs can occur below 10,000 ft.
- ☐ Rapid velocity changes affect seismic results.

  May be very weakly reflected in overlying beds.
- ☐ Pattern shooting and multiple geophones improve record quality.
- ☐ Often occur in trends; watch for "critical dip."

DISCUSSION

The Ellenburger limestone in West Texas has been the primary target since the first production at Big Lake in 1928, and many of the buried Ellenburger structures are weakly reflected in the overlying Permian beds. Shooting in West Texas is complicated by rapid velocity changes, large areas of poor reflections, and insufficient subsurface control, especially in the Delaware basin. Geophysicists, however, are overcoming these hurdles and West Texas through the years remains near the top among the best shooting areas in the country when judged in terms of the oil found. Multiple geophones and pattern shooting have helped improve record quality and made reliable interpretation possible.

Nevertheless, finding these buried structures is no easy task. The best mapping horizon, the Devonian, is an unconformity surface and locally is absent. Thus it is difficult to get a detailed picture of the Ellenburger structure. Experience in both geophysical field work and interpretation coupled with well-designed seismic programs, however, will continue to find more Ellenburger fields.

- ☐ Detailed shooting best approach.
- ☐ Pseudostructure below reef a good indication.
- ☐ Isopach interval between beds above and below reef.
- ☐ May be weakly reflected in overlying beds.

Production from the Leduc and Scurry reefs injected a new type of trap into exploration thinking, and geophysicists were soon able to come up with a technique for mapping this special form of stratigraphic trap. It is possible to map the reef surface, and the resulting seismic map resembles a symmetrical anticline. Another and more reliable method is to isopach the interval between two beds, one just above the reef, the other just below the reef. Seismic energy passes through the reef material more quickly than through the surrounding shales. The result is a pseudoanomaly or nonexistent thinning that is mapped when shooting across a reef. This false structure is evident on cross sections and geophysicists consider this is excellent evidence for the existence of a reef. Although gravity surveys have been used successfully in mapping reef trends, the reflection seismograph is the best tool for finding new reefs.

Reefs occur in trends and are usually confined to a definite stratigraphic interval.

- ☐ Tie seismic data to well control.
- ☐ Commonly occur on flanks of large structures.
- ☐ Map horizons above and below unconformity.

Production from truncated wedge edges in West Texas is confined for the most part to the flanks of large structures. On the larger Ellenburger folds, for example, the Devonian has been stripped from the crest of the fold by erosion. Downdip, however, the Devonian is present and produces.

Subsurface control is essential to the search for this type of oil trap. Trained geophysicists can even recognize the change in reflection character as the wedge edge disappears because of erosion. Velocity problems, facies changes, and depth to the reflection horizons make finding these wedge edges a real problem. However, they can be prolific oil pools. TXL has produced some 40 million barrels from the truncated Devonian, and in other fields, Ellenburger production occurs from truncated rocks under favorable conditions. Undoubtedly more wedge-edge fields will be uncovered in the next few years.

- ☐ Tie seismic survey to wells; subsurface control absolutely essential.
- ☐ Check closely area of updip convergence.
- ☐ Watch for downdip reflections that disappear updip.

Discovery of Strawn and Canyon sand production in west-central Texas was only the forerunner of a series of oil fields along the east side of the Midland basin. Production is controlled by the updip pinchout of a series of Pennsylvanian sands. This production emphasized the importance of this type of oil trap, and geologists and geophysicists have combined efforts to uncover similar new fields. Detailed shooting can isolate favorable areas and with subsurface control, the results can be very encouraging. More often than not, the sands pinchout in areas of updip convergence. And the pinchouts frequently occur along the flanks of large regional features, including large anticlines.

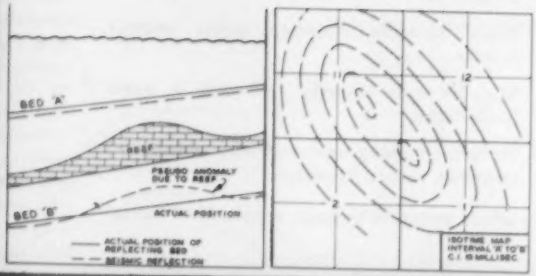
According to qualified geophyicists, seismic surveys may be used to identify and map the sandstones themselves because the seismogram in a sense serves as an electric log to trace pinchouts. The reflecting sand bodies can be traced updip until the reflection finally disappears.

CANADA

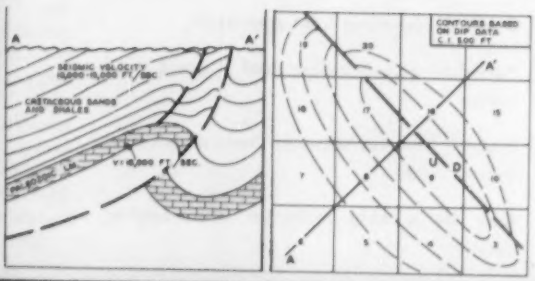
Oil finding in Canada has not reached maturity because much of the country's tremendous oil potential is virtually untapped. Oil traps range from complex folds like Turner Valley to sand lens production. Reefs are still high on the priority list and the search for another "Leduc" continues unabated. Oil companies rely heavily on geophysics because of the glacial drift, muskeg or Cretaceous sediments that completely obscure the deep structural picture. Seismic exploration is restricted to the winter months in many areas in Canada because of the terrain.

MAIN TARGETS

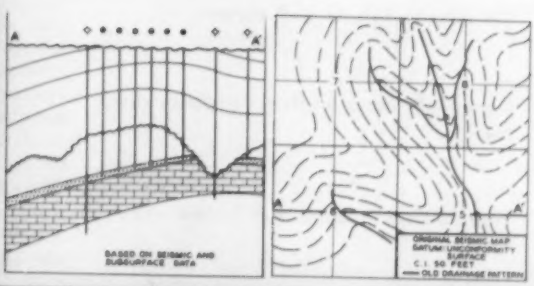
REEFS



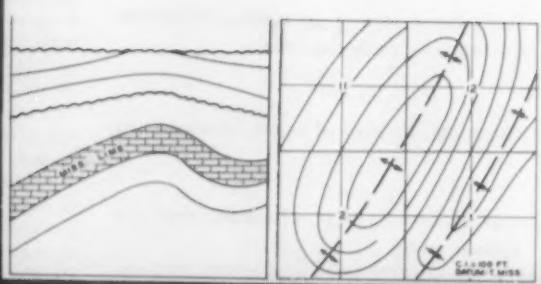
FOOTHILLS FOLD



STRAT TRAPS



ANTICLINES



SEISMIC FEATURES — DISCUSSION

- ☐ Usually occur in Devonian rocks.
- ☐ Wide depth range, 1,000 to 10,000 ft.
- ☐ Isotime and isopachous maps best method of mapping.
- ☐ Look for steep dips from flank of reef.

Reef production long has been uppermost in the minds of Canadian oil finders and 1955 wildcats indicate that the prolific reefs are present southeast of Sturgeon Lake and 75 miles northwest of Leduc. This means that many more reef fields remain to be discovered and the job of finding them rests squarely on the geophysicist, because past results show that geophysics is particularly effective in uncovering new reefs.

Isopachous maps and structural maps can be used to locate the reef. The reef is evident as a time anomaly or "thin"; or, if conditions are favorable, the reef surface shows up as a fairly simple anticline. Frequently on the seismic sections, steep dips provide the clue as to the presence of the reef. Reefs are prolific oil producers and more often than not have high reserves; for example, the Leduc-Woodbend reef will ultimately produce 170 million barrels of oil.

- ☐ Occur in long, narrow trends.
- ☐ Both reflection and refraction shooting valuable.
- ☐ Dip control necessary, usually with continuous profiling.
- ☐ Seismic sections provide much valuable information.

Oil companies are using both reflection and refraction surveys to map in the Canadian foothills. The refraction work is successful in delineating the larger structural trends because of the velocity contrast between the high velocity Mississippian limestone and the lower velocity Cretaceous sandstones and shales. In many parts of Canada, exploration work is still in a reconnaissance phase with the primary target being large, easily mapped structures. Thrust faulting with repetition of the section handicaps the oil finder and extreme care is needed in both field techniques and in interpretation. Continuous line profiling coupled with four-way spreads for dip control is an effective way of mapping in the foothills. Geophysical operations are costly with crews restricted to winter operations in many of the remote areas.

- ☐ Often related to unconformities.
- ☐ Need both seismic and subsurface control.
- ☐ Isopachous maps extremely useful.

Surprisingly enough, much of Canada's oil production is controlled by stratigraphy. Pembina with 500 million barrels of recoverable reserves is the oustanding example, but Smiley and Coleville are typical of the smaller strat traps.

Fields in this category are attractive from an independent's point of view because they are found at fairly shallow depths and usually they occur in areas where drilling is not very expensive when compared to the high cost of foothills drilling. Theoretically, geophysics can be used to locate stratigraphic plays and where structure plays a role, it is an invaluable tool in helping to outline the trap.

At Coleville, production is related to an unconformity surface and seismic surveys give an accurate contour map of the erosional surface. This map when coupled with subsurface data is an excellent guide particularly for development drilling.

- ☐ Occur in trends related to regional geology.
- ☐ If low relief, closed loop shooting best method of mapping.
- ☐ Velocity and well control essential.

Canadian geologists still place the anticline high on their list as a potential oil or gas trap. One of the largest known producing anticlines in Canada is the Peace River trend where gas occurs along the crest of a fold that is at least 25 miles long.

Subsurface unconformities complicate the seismic picture in parts of Canada. And many buried topographic highs have been drilled under the assumption that an anticline had been mapped. Expert geophysicists, however, can distinguish between buried topography and structure since the maps of the former do not resemble typical geologic structures.

The local and regional geology determines the type of field method used in Canada; i.e., refraction or reflection survey, closed loop shooting or continuous line profiling coupled with dip shooting, etc. Surveys, of course, are tied to wells if subsurface control is available on the prospect.

In conclusion . . .

Here's a quick test for successful exploration

Successful exploration work is just like any other successful operation; it requires careful planning. You must take certain steps to achieve the best results as outlined on the previous pages. Each of these steps is a "Plateau" that brings you closer to the final goal, a new oil field.

See what your score is. See if you can reach the "Drilling Plateau" on the strength of your present exploration program. With a well-designed program in good oil country, your chances of finding a new field can be as high as 1 in 3. With a poorly designed program, the odds against you are 1 in 9.

PLANNING THE SEISMIC PROGRAM

YES	NO	
1. ___	___	Have you defined your prospect or area of interest, using sound geological thinking based on the local and regional geology?
2. ___	___	Does the acreage situation justify the survey?
3. ___	___	Can geophysical methods map the lead?
4. ___	___	Have you checked the old shooting and the latest well data to see if your preliminary subsurface interpretation is correct?
5. ___	___	Have you discussed shooting techniques, permitting, local field problems, etc. with geophysicists experienced in the area?
6. ___	___	Have you decided upon a preliminary seismic program?
7. ___	___	Is your preliminary program elastic enough that it can be modified or altered if field results justify the change?
8. ___	___	Can you obtain sufficient velocity information to insure accurate results?
9. ___	___	Will you supply the party chief with all available information on the lead?
10. ___	___	Have you held a preliminary meeting with the party chief and your geologist and discussed fully the program, regional and local geology, desired information, etc.

If you answered "Yes" to at least 7 of the above questions, you are conducting a well-designed seismic exploration program.

If your score is 5-7, your procedure is considered fair.

A score of less than 5 indicates a poorly designed seismic program.

SHOOTING PROCEDURES IN THE FIELD

1. ___	___	Are you using a crew that is familiar with the area?
2. ___	___	Does your party chief have all the necessary information in the way of subsurface geological maps, aerial photographs, ownership plats, etc.
3. ___	___	Will it be necessary to conduct field tests to obtain usable seismograms?
4.		Considering the size of the prospect, local and regional geology, and field conditions, are you using the optimum:
___	___	a.) Spread distance
___	___	b.) Geophone patterns
___	___	c.) Shot hole depth
5. ___	___	Are you keeping the home office or client advised as to the field results?
6. ___	___	Are you getting the desired seismic results (i.e., reflections close to the anticipated pay zone, good records, etc.)?
7. ___	___	Are you tying the seismic survey to all wells on the prospect?
8. ___	___	Do field results indicate a satisfactory seismic program?

If you answered "Yes" to 5 or more of the above questions, your field program is satisfactory; a score below 5 is considered unsatisfactory.

INTERPRETATION AND COORDINATION OF RESULTS

1. ___	___	Has the interpreter discussed the local and regional geology with your geologist?
2. ___	___	Have you decided what geophysical information you want such as structural maps, isopachous maps, etc?
3. ___	___	Do the seismic loops tie?
4. ___	___	Does the seismic survey check with the subsurface data?
5. ___	___	Does the interpretation fit into the local and regional picture?
6. ___	___	Does the shooting confirm the original interpretation?
7. ___	___	Do you need additional shooting prior to staking the initial well?
8. ___	___	Can you supply management with the required maps?
9. ___	___	Did the geologist and party chief carefully review the final maps and reach agreement on the interpretation?
10. ___	___	Have you recommended the optimum location based on the seismic and subsurface data?

If you answered "Yes" to 5 or more of the above questions, your interpretation should prove reliable.

THE $64,000 QUESTION:

Did the initial test, applying the instructions given in this article uncover a new oil field? YES ___ NO ___

If you have a "Yes" answer to the above $64,000 question, you need no better proof that geophysics is invaluable in oil finding. If your answer is "No," however, you will find it profitable to hold a post mortem. Be sure to answer the questions listed below before farming out or dropping your leases.

POST-MORTEM ON THE ORIGINAL "PROSPECT" (if necessary)

1. ___	___	Did the initial test check the seismic interpretation?
2. ___	___	Did, you consider all deeper and shallower zones before plugging the well?
3. ___	___	If the initial test was in wildcat territory, did you run a velocity survey before plugging or completing it?
4. ___	___	Does the new velocity data alter the original interpretation?
5. ___	___	Have you reviewed the seismic data using the new well control?
6. ___	___	Is the lead definitely condemned by the initial test?
7. ___	___	Is additional shooting justified before dropping your leases or staking a new test?
8. ___	___	Do you plan to use seismic data for locating development wells?
9. ___	___	If so, do you need additional shooting to detail the structure?

You are the best judge of your score on this part of the quiz. Your post mortem is worth while, however, if you answererd at least 5 of the questions in the affirmative.

WHERE TO DRILL?
That's the most important question in the oil industry. For twenty years, General Geophysical Company has been putting the percentage for *successful* exploration in the favor of their customers.
Today General has the experienced crews, the most modern geophysical equipment (completely portable) and the recognized ability to locate conditions favorable for finding new oil reserves—
ANYWHERE IN THE WORLD.
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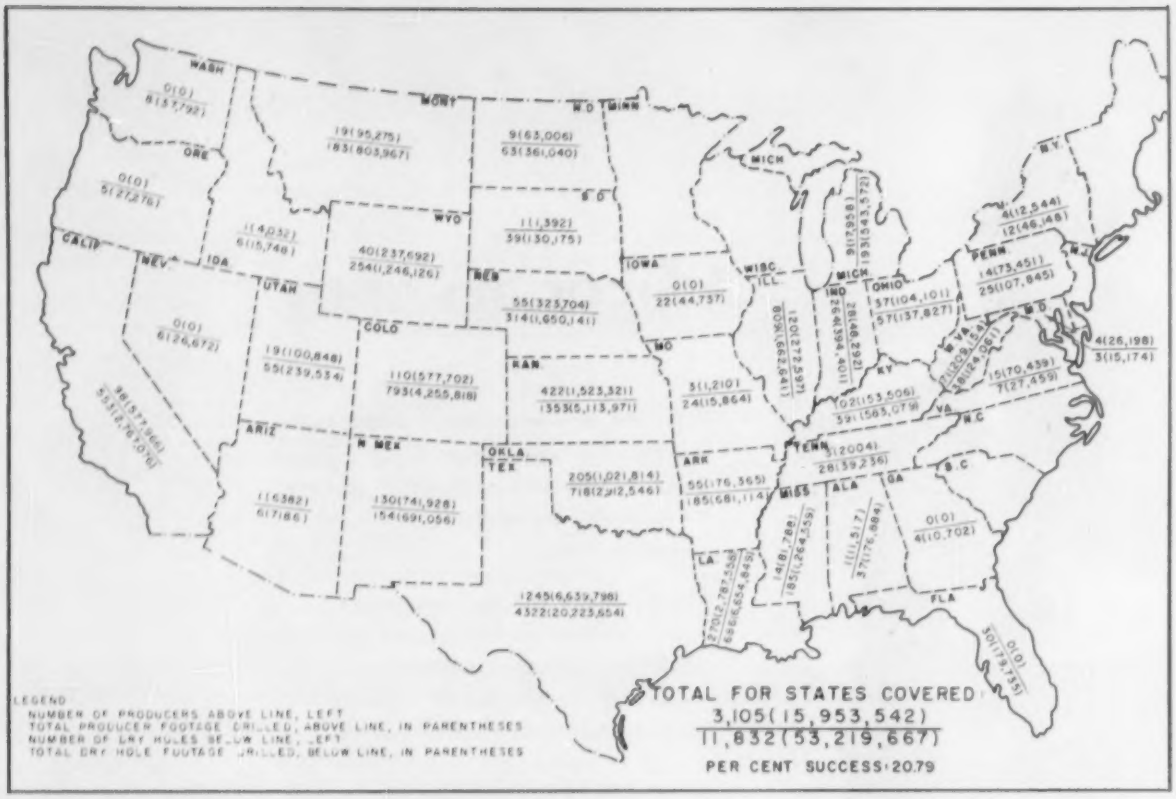
LEGEND
NUMBER OF PRODUCERS ABOVE LINE, LEFT
TOTAL PRODUCER FOOTAGE DRILLED, ABOVE LINE, IN PARENTHESES
NUMBER OF DRY HOLES BELOW LINE, LEFT
TOTAL DRY HOLE FOOTAGE DRILLED, BELOW LINE, IN PARENTHESES
TOTAL FOR STATES COVERED
3,105(15,953,542)
11,832(53,219,667)
PER CENT SUCCESS-20.79

EXPLORATORY DRILLING in 1955 showed an increase of 1,840 wells over 1954, a total of 14,937 contrasted to 13,097. Fig. 1.

Based on fields with a 6-year development history, study shows . . .

Only 1 New-Field Wildcat in 44 Drilled Discovers a Million-Barrel Field

In 1955, 20.79 per cent of holes, 23.06 per cent of footage hit pay

by Frederic H. Lahee

IN the last 11 years in the United States, new-field wildcats have comprised 54.58 per cent of the total number of exploratory holes. Of these new-field wildcats, during the last 11 years, the percentage located on technical advice has risen from 85 per cent to over 90 per cent. In this same period near three times (2.8) as many new-field wildcats have been successful when located on technical advice as those not so located. Taking all new-field wildcats into consideration there has been an almost constant success-to-failure ratio. The average for the 11 years has been 11.21 per cent, with a range from a low of 10.65 per cent to a high of 12.22 per cent. That is, one hole in every nine has found some oil or gas.

But even more significant than these figures has been our study of the total ultimate reserves of oil discovered by these new-field wildcats. Briefly, this study, which is based on fields having a minimum of 6 years of development history, shows that only 1 new-field wildcat out of every 44 drilled discovers a field with as much as 1 million barrels of total ultimate reserves. Nearly 98 per cent of all new-field wildcats drilled are failures in that they are abandoned as dry or they discovered reserves too small, on the average, to be profitable.

The industry drilled 14,937 exploratory holes during 1955 for a total of 69,173,209 ft.

These are divided as follows:

	Feet
3,105 producers	15,953,542
11,832 dry holes	53,219,667

This means that 20.79 per cent of the holes drilled, and 23.06 per cent of the footage drilled, were successful

This abridgment of the report of the chairman of the American Association of Petroleum Geologists' Committee on Exploratory Statistics, presented at the association's annual meeting in Chicago, April 23-26, is published by special permission of the author and the A.A.P.G. The full report will be published in the June bulletin of the A.A.P.G.

TABLE I. CLASSIFICATION OF EXPLORATORY WELLS

				I. *Classification When Drilling It Started*	II. *Classification after Completion or Abandonment*	
					Successful	*Unsuccessful*
				A	*B*	*C*
Drilling for long extension of partly developed pool				1 Outpost. (Extension test)	1 Extension well (Sometimes a new-pool discovery well)	1 Dry outpost (Dry extension test)
Drilling for a new pool on a structure or in a geological environment already productive	New-pool tests	Drilling within limits of proved area of pool	For new pool above deepest pool	2a Shallower-pool test	2a Shallower-pool discovery well (Sometimes shallower-pool extension well)	2a Dry shallower-pool test
			For new pool below deepest pool	2b Deeper-pool test	2b Deeper-pool discovery well (Sometimes deeper-pool extension)	2b Dry deeper-pool test
		Drilling outside limits of proved area of pool		2c New-pool wildcat	2c New-pool discovery wildcat (Sometimes an extension well)	2c Dry new-pool wildcat
Drilling for a new field (on a structure or in an environment never before productive)				3 New-field wildcat	3 New-field discovery wildcat	3 Dry new-field wildcat

1955 Wildcatting

THE AUTHOR

F. H. Lahee, consultant, Dallas, was graduated by Harvard University with a B.A. degree in 1907. He received his M.A. degree in 1908 and his Ph.D. in 1911. He taught at Harvard from 1906-1912 and at M.I.T. from 1912 to 1918. He joined Sun Oil Co. in 1918 and was chief geologist from 1920-1940. During the period 1929-1932, Dr. Lahee was editor of the Bulletin of the American Association of Petroleum Geologists, and from 1932 to 1933 was president of that association. In 1953 the A.A.P.G. awarded him the Sidney Powers Memorial Medal. For the past several years prior to his retirement, Dr. Lahee was geological and research counselor for Sun Oil Co. in Dallas. He is now a consulting geologist in Dallas.

TABLE 2—NUMBER OF OIL WELLS, GAS WELLS, CONDENSATE WELLS, AND DRY HOLES DRILLED IN UNITED STATES AS EXPLORATORY TESTS IN 1955

	Oil producers		Gas producers		Condensate producers		Total producers		Dry holes		Grand total		
State—	No. of holes	Footage	No. of holes	Footage	No. of holes	Footage	No. of holes	Footage	No. of holes	Footage	No. of holes	Footage	Average depth of hole*
Alabama	1	11,517	0	0	0	0	1	11,517	37	176,884	38	188,401	4,958
Arizona	0	0	0	0	1	6,382	1	6,382	6	7,186	7	13,568	
Arkansas	48	150,838	6	20,597	1	4,930	55	176,365	185	681,114	240	857,479	3,573
California	79	475,395	19	92,571	0	0	98	567,966	553	2,767,076	651	3,335,042	5,123
Colorado	67	357,512	41	207,809	2	12,381	110	577,702	793	4,255,818	903	4,833,520	5,353
Florida	0	0	0	0	0	0	0	0	30	179,735	30	179,735	5,991
Georgia	0	0	0	0	0	0	0	0	4	10,702	4	10,702	
Idaho	0	0	1	4,032	0	0	1	4,032	6	15,748	7	19,780	
Illinois	113	267,679	7	4,918	0	0	120	272,597	809	1,662,641	929	1,935,238	2,083
Indiana	27	47,523	1	769	0	0	28	48,292	264	394,401	292	442,693	1,516
Iowa	0	0	0	0	0	0	0	0	22	44,737	22	44,737	
Kansas	344	1,176,450	78	346,871	0	0	422	1,523,321	1,353	5,113,971	1,775	6,637,292	3,739
Kentucky	81	113,416	21	40,090	0	0	102	153,506	391	583,079	493	736,585	1,494
Louisiana	129	1,223,368	54	530,769	87	1,033,421	270	2,787,558	686	6,654,849	956	9,442,407	9,877
Maryland	0	0	4	26,198	0	0	4	26,198	3	15,174	7	41,372	
Michigan	7	13,256	2	4,702	0	0	9	17,958	193	543,572	202	561,530	2,780
Mississippi	12	67,332	1	4,688	1	9,768	14	81,788	185	1,264,559	199	1,346,347	6,766
Missouri	3	1,210	0	0	0	0	3	1,210	24	15,864	27	17,074	632
Montana	13	74,903	6	20,372	0	0	19	95,275	183	803,967	202	899,242	4,452
Nebraska	53	314,593	2	9,111	0	0	55	323,704	314	1,650,141	369	1,973,845	5,349
Nevada	0	0	0	0	0	0	0	0	6	26,672	6	26,672	
New Mexico	79	559,586	46	149,323	5	33,019	130	741,928	154	691,056	284	1,432,984	5,046
New York	0	0	4	12,544	0	0	4	12,544	12	46,148	16	58,692	
North Dakota	9	63,006	0	0	0	0	9	63,006	63	361,040	72	424,046	5,889
Ohio	16	50,114	21	53,987	0	0	37	104,101	57	137,827	94	241,928	2,574
Oklahoma	144	707,513	47	217,457	14	96,844	205	1,021,814	718	2,912,546	923	3,934,360	4,263
Oregon	0	0	0	0	0	0	0	0	5	27,278	5	27,278	
Pennsylvania	0	0	14	73,451	0	0	14	73,451	25	107,845	39	181,296	4,649
South Dakota	1	1,392	0	0	0	0	1	1,392	39	130,175	40	131,567	3,289
Tennessee	3	2,004	0	0	0	0	3	2,004	28	39,236	31	41,240	1,330
Texas	971	4,893,535	143	728,928	131	1,017,335	1,245	6,639,798	4,322	20,223,654	5,567	26,863,452	4,825
Utah	5	30,602	14	70,246	0	0	19	100,848	55	239,534	74	340,382	4,573
Virginia	0	0	15	70,439	0	0	15	70,439	7	27,459	22	97,898	
Washington	0	0	0	0	0	0	0	0	8	37,792	8	37,792	
West Virginia	2	4,513	69	204,641	0	0	71	209,154	38	124,061	109	333,215	3,057
Wyoming	29	154,275	11	83,417	0	0	40	237,692	254	1,246,126	294	1,483,818	5,047
Total U. S.	2,236	10,761,532	627	2,977,930	242	2,214,080	3,105	15,953,542	11,832	53,219,667	14,937	69,173,209	4,631
Average depth per hole		4,812		4,749		9,149		5,138		4,498		4,631	

*Average per well footage given only where 25 or more wells were drilled in the state.

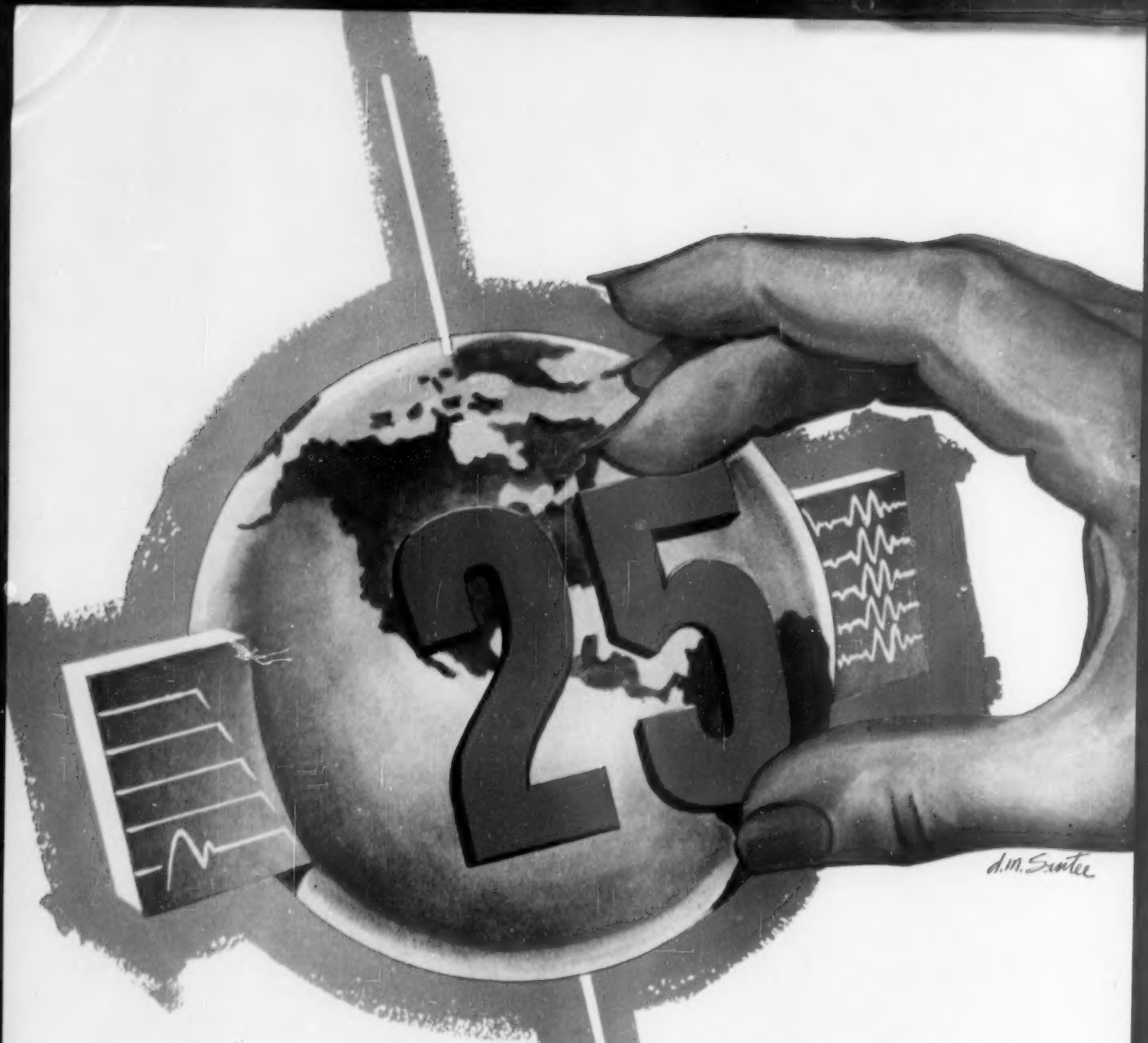

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TABLE 3—BASIS FOR LOCATING NEW-FIELD WILDCATS DRILLED IN 1955

State—	Geology		Geophysics		Geology and geophysics		Sundry nontechnical		Unknown		Total		Grand total
	Producers	Dry holes	Producers	Dry holes	Producers	Dry holes	Producers	Dry holes	Producers	Dry holes	Producers	Dry holes	
Alabama	1	22	0	4	0	6	0	1	0	1	1	34	35
Arizona	0	1	0	1	1	0	0	0	0	4	1	6	7
Arkansas	10	101	0	7	0	4	0	0	0	19	10	131	141
California	10	132	0	12	5	59	0	51	0	10	15	264	279
Colorado	41	374	2	33	12	107	0	23	6	130	61	667	728
Florida	0	6	0	20	0	0	0	3	0	1	0	30	30
Georgia	0	1	0	1	0	0	0	0	0	2	0	4	4
Idaho	0	0	0	0	0	0	0	1	1	5	1	6	7
Illinois	27	265	0	8	0	0	4	36	0	0	31	309	340
Indiana	6	209	0	0	0	0	0	0	1	0	7	209	216
Iowa	0	0	0	0	0	0	0	0	0	22	0	22	22
Kansas	12	64	3	56	0	10	1	1	6	101	22	232	254
Kentucky	10	65	0	0	0	0	0	0	8	64	18	129	147
Louisiana	9	183	37	65	23	110	0	0	0	1	69	359	428
Michigan	5	128	2	16	0	0	0	0	0	0	7	144	151
Mississippi	9	123	0	13	0	24	0	0	0	12	9	172	181
Missouri	0	0	0	0	0	0	0	0	0	24	0	24	24
Montana	2	73	3	22	4	63	0	5	0	0	9	163	172
Nebraska	3	39	10	82	0	0	15	120	0	9	28	250	278
Nevada	0	0	0	3	0	0	0	1	0	2	0	6	6
New Mexico	20	49	12	27	2	4	0	18	0	6	34	104	138
New York	2	9	0	0	0	0	0	1	0	0	2	10	12
North Dakota	0	4	2	8	4	38	0	1	0	9	6	60	66
Ohio	1	2	0	2	0	0	0	1	0	0	1	5	6
Oklahoma	22	193	6	47	26	109	0	0	0	0	54	349	403
Oregon	0	3	0	0	0	2	0	0	0	0	0	5	5
Pennsylvania	0	3	0	0	0	0	0	0	2	6	2	9	11
South Dakota	1	25	0	2	0	12	0	0	0	0	1	39	40
Tennessee	0	10	0	0	0	0	0	0	0	17	0	27	27
Texas	237	1,975	64	293	97	364	9	106	76	425	483	3,163	3,646
Utah	8	29	3	8	1	4	0	5	0	4	12	50	62
Virginia	9	1	0	0	0	0	0	0	0	0	9	1	10
Washington	0	1	0	0	0	4	0	3	0	0	0	8	8
West Virginia	6	3	0	0	0	0	2	4	0	0	8	7	15
Wyoming	3	83	5	25	8	48	1	30	0	2	17	188	205
Total	454	4,176	149	*755	183	968	32	411	100	876	918	7,186	8,104

*Includes five dry holes based on geochemistry.

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in 1955. One producer foot was drilled for every 3.34 ft. of dry hole. One successful well was drilled for every 3.81 dry holes. The average depth of hole was 4,631 ft.

Attention is called to the average depth figures for the various producing classes and for dry holes, and totals, at the bottom of the footage columns in Table 2.

Reasons for drilling . . . In Table 3 are listed the reasons for drilling the **new-field wildcats** in 1955, by using the best information available from men familiar with such statistics, each in his own state or district. According to these figures 786 new-field wildcats drilled on technical advice (geology or geophysics or both) were successful, and 5,899 were dry; 32 holes, located for nontechnical reasons, were producers, and 411 were dry; 100 producers and 876 dry holes were located for reasons unknown. These figures show that 11.7 per cent of the new-field wildcats drilled on technical advice were producers as contrasted with 7.2 per cent successful in the case of holes located without technical advice.

TABLE 4—RELATIVE SUCCESS OF EXPLORATORY DRILLING IN UNITED STATES FROM 1944 TO 1954, INCLUSIVE

Year	New-field wildcats		All exploratory holes	
	Number of dry holes for each producer	Percentage of wells successful	Number of dry holes for each producer	Percentage of wells successful
1944	8.05	11.05	4.08	19.67
1945	7.63	11.59	3.62	21.64
1946	8.39	10.65	4.06	19.76
1947	7.80	11.32	3.90	20.34
1948	7.57	11.66	4.50	18.25
1949	7.79	11.37	3.95	20.20
1950	7.93	11.19	4.11	19.54
1951	8.05	11.05	4.30	18.86
1952	8.05	11.06	4.32	18.78
1953	7.95	11.18	3.98	20.13
1954	7.18	12.22	3.83	20.68
1955	7.82	11.32	3.81	20.78
1944-1955, inclusive	7.92	11.21	4.03	19.88

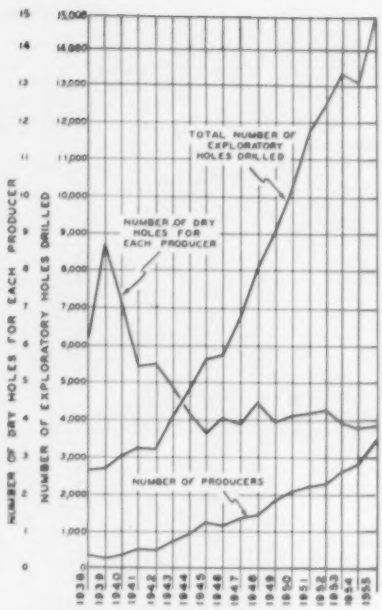
TABLE 5—FIELDS* DISCOVERED IN 1949 AND 1952 GROUPED ACCORDING TO THEIR TOTAL ULTIMATE RESERVES AS ESTIMATED JANUARY 1, 1956

Year	Number of fields discovered in year indicated by reserves groups†						Total A — F inclusive	A + B + C fields	Percentage of A + B + C fields in total fields
	A	B	C	D	E	F			
1949	10	4	11	83	222	86	416	25	6.01
1952	2	1	12	78	407	99	599	15	2.50

*This table refers only to the states of Alabama, Arkansas, California, Colorado, Illinois, Indiana, Kansas, Kentucky, Louisiana, Michigan, Mississippi, Montana, Nebraska, New Mexico, Oklahoma, Texas, and Wyoming. It does not include gas fields unless natural-gas liquids are produced, and then the reserves figure relates only to these liquids. A few fields were omitted because of inadequate estimates, and a few producing areas, at first thought to be new fields, have become consolidated with other fields.

†In this table, A means 50 million barrels or more, B means between 25 and 50 million barrels, C means between 10 and 25 million barrels, D means between 1 and 10 million barrels, E means less than 1 million barrels, F means abandoned.

EXPLORATORY DRILLING in Canada enjoyed a success ratio of 25 per cent, about on a par with the 1954 record. Fig. 2.


TOTAL NUMBER OF EXPLORATORY HOLES DRILLED
NUMBER OF DRY HOLES FOR EACH PRODUCER
NUMBER OF PRODUCERS
NUMBER OF DRY HOLES FOR EACH PRODUCER
NUMBER OF EXPLORATORY HOLES DRILLED

RELATIVE SUCCESS of exploratory drilling in the United States from 1939 to 1955. Fig. 3.

1955 Wildcatting

Therefore, in 1955, locations for new-field wildcats based on technical recommendations were 1.6 times as successful as those drilled without such advice. Seismographic methods were largely responsible for 321 producers and 1,659 dry holes, among the new-field wildcats.

Table 4 shows the relative success, as measured by the number of producers in comparison with the number of dry holes, in each year from 1944 to 1955, inclusive.

Reserve data . . . Some years ago we included in our annual report a table showing the number of fields discovered each year, from 1938 to the year preceding the year reported, these fields being grouped according to a rough estimate of their total ultimate reserves from the date of discovery. The fields were grouped according to these estimates: "A" meaning a total ultimate of 50 million barrels or more; "B," from 25 to 50 million barrels; "C," from 10 to 25 million barrels; "D," from 1 to 10 million barrels; "E," less than 1 million barrels; and "F," abandoned. Gas fields were not included unless they also produced oil or condensate. A few fields were omitted where satisfactory estimates were not readily obtainable.

In the present report, we are repeating the approach followed in 1954. In other words, we are recording, in Table 5, estimated total ultimate reserves only for the discoveries of 1949 and 1952. Where necessary, revisions have been made of the earlier estimates of these fields discovered in 1949 and 1952. In revising these earlier estimates for discoveries of 1949, as made 3 years ago, 6 A's remained unchanged; 3 B's were raised to A; 1 A was lowered to B; 1 B remained unchanged; 2 C's were raised to B; 1 B was lowered to C; 3 C's remained unchanged; 6 D's and 1 E were raised to C; 1 C was lowered to D; 53 D's remained; 23 E's were raised to D; 9 D's were lowered to E; 208 E's remained unchanged; 4 F's were revived as E's, and 1 was revived as a D; 1 E went to gas; 51 E's became F's; 35 F's remained unchanged. Fifty-eight gas fields remained gas fields.

In revising the earlier estimates for 1952 (made in January 1953), 1 A remained unchanged; 1 A was lowered to C; 1 E was raised to A; 1 B remained unchanged; 3 C's remained unchanged; 5 D's and 3 E's were raised to C's; 2 C's were lowered to D's; 1 C was lowered to E; 45 D's remained unchanged; 31 E's were raised to D's; 16 D's were lowered to E's; 385 E's remained unchanged; 1 F became an E; and 1 gas well became an oil field rated as E; 87 E's became F's; 11 F's remained unchanged. Ninety-one gas fields remained gas fields.

It is our plan to make these estimates of the fields discovered in any given year only 3 and 6 years, respectively, after their dates of discovery, and to omit the rough preliminary estimate given just after their discovery.

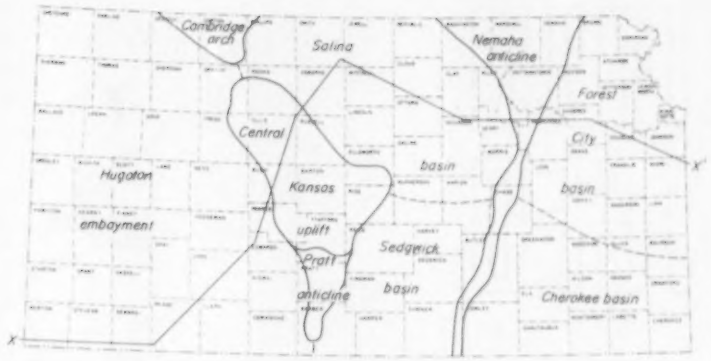
Exploratory Drilling in Canada

In western Canada, in 1955, 885 exploratory holes were completed, 246 of these being producers and 639 being dry holes. The producers included 148 oil wells and 98 gas wells. A total of 3,978,114 ft. was drilled, 1,165,975 ft. in producers and 2,812,139 ft. in dry holes. This means that 27.8 per cent of the exploratory holes and 29.3 per cent of the exploratory footage were successful. There were 2.41 ft. drilled in dry holes for every foot drilled in producers. For every producer completed 2.59 dry holes were abandoned. The average depth of all the exploratory holes was 4,495 ft.

Among the 718 new-field wildcats completed in western Canada in 1955, 152 were successful and 566 were dry. In other words, new-field wildcatting was 21.2 per cent successful. One producer was drilled for every 3.72 dry holes.

In eastern Canada, 131 exploratory holes were drilled, with a total of 219,389 ft. Of the 131 holes 9 were successful, 7 as gas wells, and 2 as oil wells. In these producers, 12,723 ft. was drilled. Of the 131 holes, 6.87 per cent were successful; 5.81 per cent of the exploratory footage was in successful holes. For every foot drilled in producers, 16.23 ft. was drilled in dry holes. The average depth of hole was 1,674.7 ft.

"In 1955, 786 new-field wildcats drilled on technical advice (geology or geophysics or both) were successful, and 5,899 were dry; 32 holes, located for nontechnical reasons, were producers, and 411 dry holes were located for reasons unknown."



Kansas' Structural Provinces

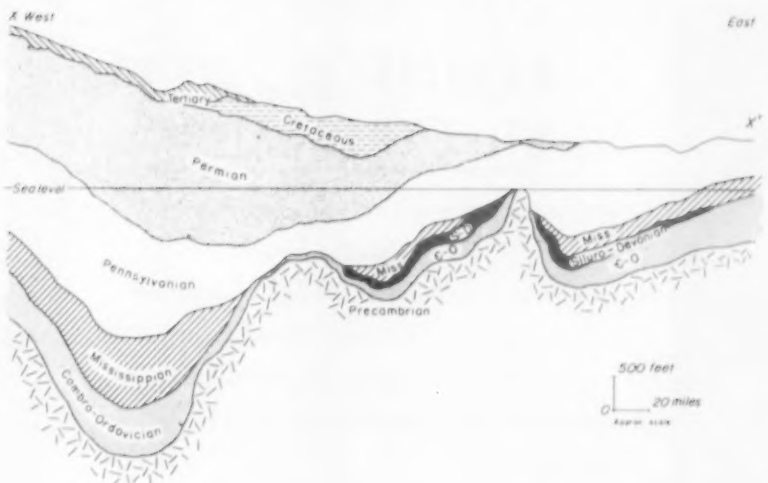


Fig. 1

Offer Varied Types of Traps

The easy discoveries have been found; better discovery methods will locate the hard ones

by Daniel F. Merriam and Edwin D. Goebel

HISTORY has shown Kansas to be a prolific producer of petroleum; indications are that it will continue to be in the future. With the possible exception of parts of the Central Kansas uplift and the Nemaha anticline, few areas have been adequately tested. Every structural province in the state has a potentially bright future, although at the present time certain areas look more favorable than others. Although an area may become inactive, sooner or later a new discovery initiates plays and excites enthusiasm about zones undreamed of before.

It is true in Kansas, as it is in most areas of the United States, that the easy discoveries have been found. Future possibilities lie in the application of new techniques or more intensive detailed exploration of the older, partly developed areas. Geophysics is playing a larger role today in new discoveries than it did 10 years ago and undoubtedly will play an even more significant part in future exploration. The modern trend is towards finding the elusive stratigraphic trap. The ratio of discovery wells is becoming smaller, but with increased activity the total number of finds continues to increase.

Forest City basin . . . Drilling depths in the Forest City basin (Fig. 1) are intermediate from 2,000 to 4,000 ft. to the top of the Arbuckle. The maximum section of sedimentary rocks encountered is about 4,000 ft. plus. Except for production from the Pennsylvanian sands, the Forest City basin has not been adequately explored, especially in the deeper parts.

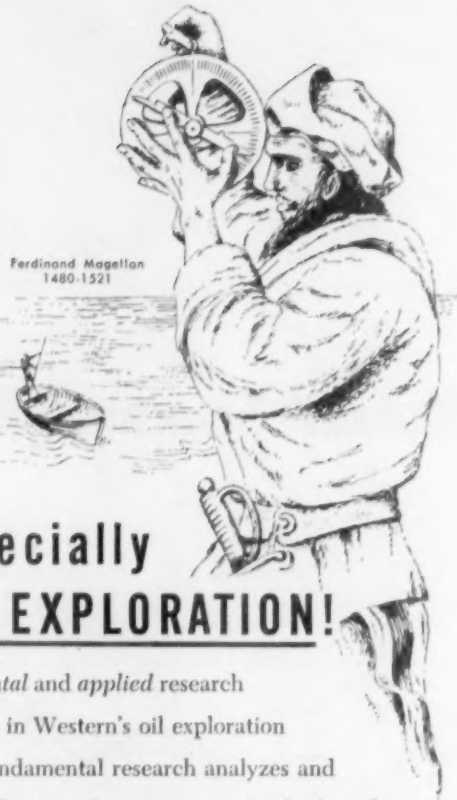
Future prospects include stratigraphic traps along the western side of the basin where the lower Paleozoic beds have been upturned, truncated, and overstepped on the flanks of the Nemaha anticline; structural and stratigraphic traps in the deeper parts of the basin in pre-Pennsylvanian beds, the Arbuckle in particular; and secondary recovery of oil from shallow Pennsylvanian sands.

Cherokee basin . . . Prospects of additional reserves in the Cherokee basin are particularly encouraging, especially in the Arbuckle rocks. The depth to the Arbuckle ranges from about 500 to 3,000 ft. and the maximum sedimentary section is about 3,500 ft. Continued development of the Pennsylvanian shoestring sands is by secondary-recovery methods. As in the Forest City basin, stratigraphic traps along the west flank and structural traps in the deeper parts of the basin seem promising.

Nemaha anticline . . . Pre-Cambrian rocks lie at depths of 500 to 3,000 ft. on the ridge, thus, the maximum section is about 3,000 ft. Closed structures on the crest and stratigraphic traps along the flanks in the northern part of the province seem to have some future. Considerable development has already taken place on the ridge south of Chase County, but there is no major production north of Morris County. Possible producing zones can be expected in the Permian and Pennsylvanian beds on both the crest and flanks and in the Mississippian, Hunton, Viola, St. Peter, and Arbuckle rocks on the flanks.

Salina basin . . . Drilling depths to the top of the Arbuckle in the Salina basin range from about 2,000 to 4,000 ft. The maximum section encountered is about 4,500 ft. Future possibilities are structural traps and combinations of structural and stratigraphic traps on the flanks. The center part of the basin is almost totally unexplored, and flank production is not completely developed. Very few wells have been drilled on the east side of the basin, and strat-

EXPLORATION HAS CHANGED



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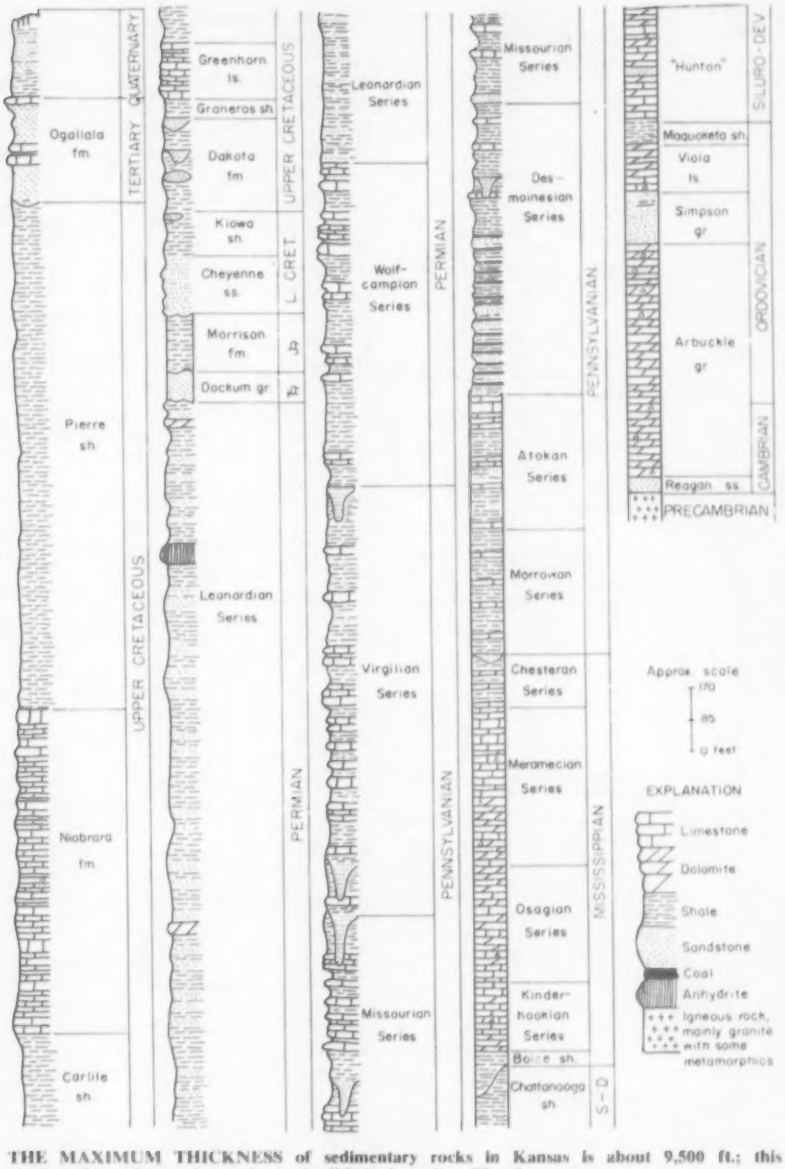

THE MAXIMUM THICKNESS of sedimentary rocks in Kansas is about 9,500 ft.; this stratigraphic column shows the main lithologic units. Fig. 2.

igraphic possibilities in the lower Paleozoic formations seemingly would be good in this area.

Sedgwick basin . . . The Sedgwick basin has many possibilities that bear some merit. The top of the Arbuckle ranges in depth from 3,000 to 5,000 ft., and the maximum section is about 5,500 ft. The Arbuckle rocks anywhere in the basin and all zones from the Permian to the pre-Cambrian in the deeper parts of the basin have merit. Future developments in the Pennsylvanian, Mississippian, Hunton, Viola, Simpson, and Arbuckle rocks can be expected. There is also a future in the secondary recovery of oil from some of the shallower zones in the basin. As in the other basins, stratigraphic traps on the flanks as well as structural traps will be important.

Cambridge arch . . . The Cambridge arch has good possibilities, although most of the arch is located in Nebraska. As drilling depths are shallow to intermediate from 3,000 to 4,000 ft. to the top of the Arbuckle; further developments should take place on the southern end of the structure in Decatur, Norton, and Phillips counties. The best possibilities seem to be the Pennsylvanian, especially the Lansing-Kansas City section, and the Arbuckle and Reagan. So far, however, results from the Lansing-Kansas City have been discouraging.

Kansas Exploration

Central Kansas uplift . . . Possibilities on the Central Kansas uplift are good, if one can find a section of land that has not been adequately tested. The offsetting of old wells that had good shows, and application of new engineering techniques, both offer promise. The drilling depths are intermediate, the top of the Arbuckle being 3,000 to 4,500 ft. deep. A maximum section of about 5,000 ft. can be expected. Almost all rocks have possibilities; the Arbuckle in particular has been a prolific reservoir bed. Structural and stratigraphic traps on the flanks are future possibilities.

Pratt anticline . . . Although the province is relatively small in areal extent, the possibilities seem to be good. Drilling depths are intermediate; the top of the Arbuckle is about 4,500 ft. and the maximum sedimentary section is about 5,000 ft. There are good possibilities from the lower Paleozoic beds and in particular the Mississippian, Simpson, Viola, and Arbuckle.

Hugoton embayment . . . This structural province has not yet been adequately tested. The Hugoton gas area has been the gage of things in this province for many years so with the

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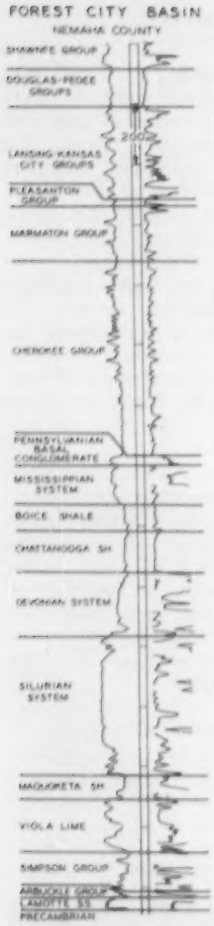
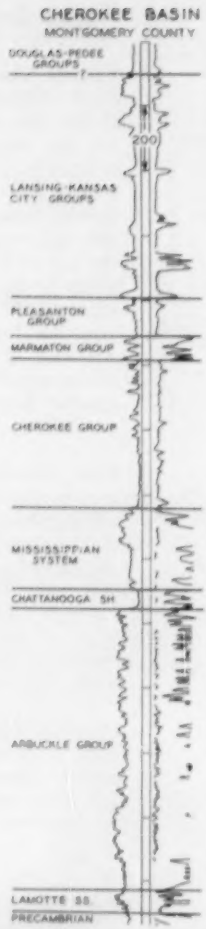
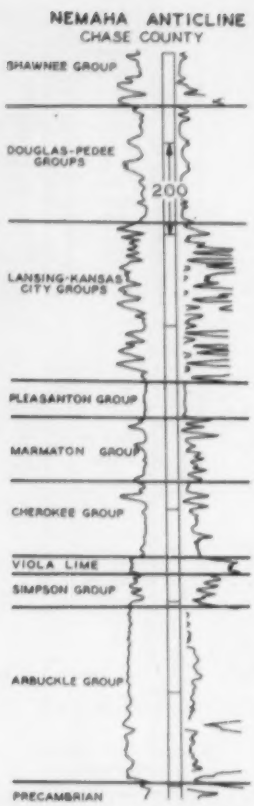


DRILLING depths of 2,000 to 4,000 ft. make the Forest City basin attractive to independents. Many of the older Pennsylvanian sand fields have been rejuvenated by waterflooding. Fig. 3.



CHEROKEE basin offers both structural and stratigraphic traps. Depth to the Arbuckle ranges from 500 to 3,000 ft. Fig. 4.



PERMIAN and Pennsylvanian zones may produce both on the crest of the Nemaha anticline and along the flanks. The Mississippian, Hunton, Viola, St. Peter, and Arbuckle rocks offer possibilities on the flanks of this positive trend. Fig. 5.

discovery of oil in the Arbuckle in Scott County last year the whole complexion of the embayment changed almost overnight. Production from the lower Pennsylvanian and upper Mississippian beds has been encouraging, but now there are also possibilities from the Arbuckle. Drilling depths can be considered deep to the Arbuckle, as the depth to the top ranges from about 3,500 to 8,500 ft. and the maximum possible section of oil sedimentary rocks is about 9,500 ft. Future possibilities include everything from the Cretaceous to the pre-Cambrian and from both structural and stratigraphic traps.

History . . . Kansas is still a mighty fertile hunting ground for the geologist seeking additional reserves of hydrocarbons.

Although never the leader of the oil and gas producing states, Kansas has maintained membership in the top six for the last 38 years, Fig. 10. Since the first oil well was drilled in 1860 near Paola in Miami County, about 45 miles southwest of Kansas City, the petroleum industry in Kansas has spread from border to border. As each oil province in the state reached maximum production, a new province has been explored, not found wanting, and developed for still additional reserves of hydrocarbons.

A milestone in Kansas productive history was the discovery in 1914 of commercial oil production from pre-Pennsylvanian rocks in Butler County. This was, of course, the discovery of the El Dorado-Augusta area. Further exploration along the mappable surface structures of the El Dorado trend led to the delineation of the Nemaha granite ridge, which in turn required a reinterpretation of the subsurface structure of central and western Kansas. The resulting exploration led to the

Kansas Exploration

discovery of important new reserves in what was later known as the Sedgwick basin. Also discovered through the El Dorado-inspired exploration was the "Golden Trend," now known to be post-Mississippian lenticular sand bodies only indirectly controlled by the adjacent Nemaha ridge.

The next marker in Kansas productive history came in 1922 with the discovery of the tremendous Permian gas area, Hugoton field. Subsequent drilling has discovered additional reserves in older rocks and has delineated the Hugoton embayment.

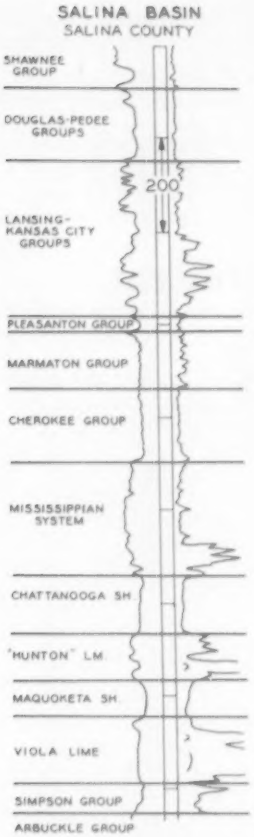
Surface mapping of a conspicuous structure, as the El Dorado, was destined again to be the clue to the presence of another major Kansas oil province, the Central Kansas uplift area. In 1923, the Cambro-Ordovician rocks in the Fairport anticline, Ellis and Russell counties, were found to be both shallow and productive. The new reserves, being a great distance from other oil areas, served as an incentive to drilling in other western Kansas areas. Thus, the Salina basin was delineated and the Sedgwick basin better defined.

Refinement of Kansas structural provinces has been made possible through the continued search for new production. Oil production was first discovered on the Pratt anticline in 1936. The most recently described refinement of Kansas structure, the Cambridge arch, came with the discovery of the Norton oil field in 1953.

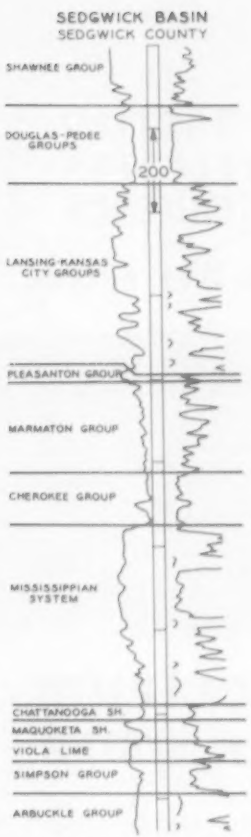
Stratigraphy

Because of the nature of this study, the discussion of the stratigraphy is by necessity short and intended to give only the briefest outline of Kansas stratigraphy. It is, of course, necessary for the better understanding of occurrences of petroleum in Kansas. For a more complete description the reader is referred to Moore and others (1951). A generalized geologic section is shown in Fig. 2.

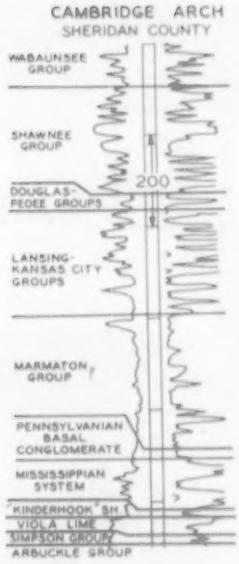
The section of the sedimentary beds in Kansas is relatively thin when compared to the deeper basinal areas such as the Denver or Anadarko basins. The maximum thickness of sedimentary rocks is about 9,500 ft. in the deepest part of the Kansas portion of the Hugoton embayment. When viewed in proper perspective, the sedimentary strata appear almost as a veneer covering the pre-Cambrian basement complex. This basement complex, of course, is nothing more than an extension of the Canadian shield area, which is exposed farther to the north and northeast. Also when compared to geosynclinal areas, the stratigraphy is seemingly



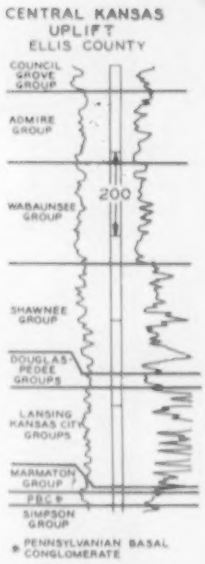
THE CENTER portion of the Salina basin is relatively unexplored. Fig. 6.



ALL ZONES from the Permian through the Arbuckle offer possibilities as reservoirs in the Sedgwick basin. Fig. 7.



SEVERAL ZONES should produce along the Cambridge arch that extends northward from Kansas into Nebraska. Fig. 8.



THE CENTRAL Kansas uplift has been thoroughly explored, but fracturing and more detailed exploration are still finding new oil. Fig. 9.

Kansas Exploration

simple and the succession of many thin beds of sediments has been compared to that of a layer cake.

Pre-Cambrian rocks . . . The basement complex of pre-Cambrian age consists mainly of igneous and metamorphic rocks. In general, it can be said that the igneous rocks occur on the uplifts and the metamorphic rocks occur in the basins. Granite is by far the more extensive rock type encountered by drilling. This is probably because of two factors: (1) the terms granite and pre-Cambrian are sometimes used synonymously to indicate crystalline rock and thus the termination of drilling, and (2) most of the areas where the pre-Cambrian is shallow enough to be encountered are on the uplifts and are granite. A weathered zone on the pre-Cambrian surface is termed "granite wash." Few wells have penetrated to the pre-Cambrian in the basins, but it would seem that metamorphic rocks occur extensively in these areas. The most common metamorphics are schist, gneiss, and quartzite. The distribution of the different rock types of the pre-Cambrian are at best only vaguely known except in areas where the crystalline rocks occur at relatively shallow depth. In Barton County on the Central Kansas uplift, Walters (1946) was able to make a study of the pre-Cambrian and interpret part of the history of these rocks. A major unconformity occurs at the top of the pre-Cambrian rocks.

Paleozoic rocks . . . The pre-Pennsylvanian rocks in Kansas consist mainly of marine sediments—limestone and dolomite and some shale and sandstone. Rocks of Cambrian, Ordovician, Silurian, Devonian, and Mississippian age are present in various parts of the state. Siluro-Devonian sediments are not known to be present in Kansas west of the Central Kansas uplift. The thickest section of these rocks occurs near the center of the different basins where they have been preserved from extensive erosion at different intervals throughout geologic history. The pre-Pennsylvanian rocks are missing from the crest of many of the uplifts. Unconformities are common and widespread in this part of the section. A major unconformity occurs between rocks of Mississippian and Pennsylvanian age.

Rocks of Pennslyvanian and Permian age occur almost over the entire state. They are characterized by cyclic sediments of marine and nonmarine strata. Thin but persistent units can be traced over large areas of the Mid-Continent region. Lateral facies changes occur between the shallow shelflike areas and the deeper basins. Breaks in this part of the section are marked by channel sandstones that usually occur at the disconformities. Disconformities are numerous, owing to the nature of the deposition of the sediments. The end of the Paleozoic is marked by a complete change in sedimentary and structural conditions.

Mesozoic rocks . . . Rocks of the Mesozoic era predominantly are thick accumulations of marine shale, limestone, and chalk. Nonmarine deposits of sandstone and shale are also widespread. Mesozoic rocks are present in about the western half of the state and increase in thickness west and northwest toward the Rocky Mountain region. The basal units of the Mesozoic overstep the older Paleozoic beds with a pronounced unconformity. The upper limits of these beds is an unconformity that indicates another complete change of geological conditions.

Tertiary rocks . . . At the end of the Mesozoic, environment changed from marine to nonmarine. The Tertiary

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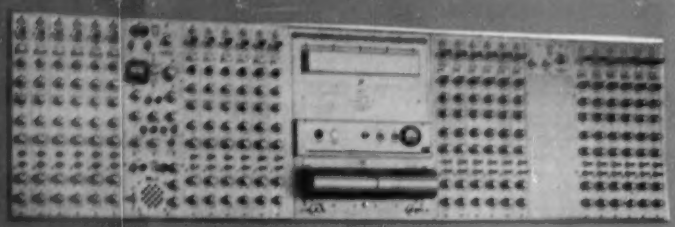

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rocks, comprising the Ogallala formation of Pliocene age, blanket the western one-third of the state. Because of the unconformity at the base of these sediments and the different structural conditions existing during the Tertiary, it is impossible to use surface structure as an indication of structure in the older beds. In effect, this mantle of more or less unconsolidated material serves to mask the underlying stratigraphy and structure.

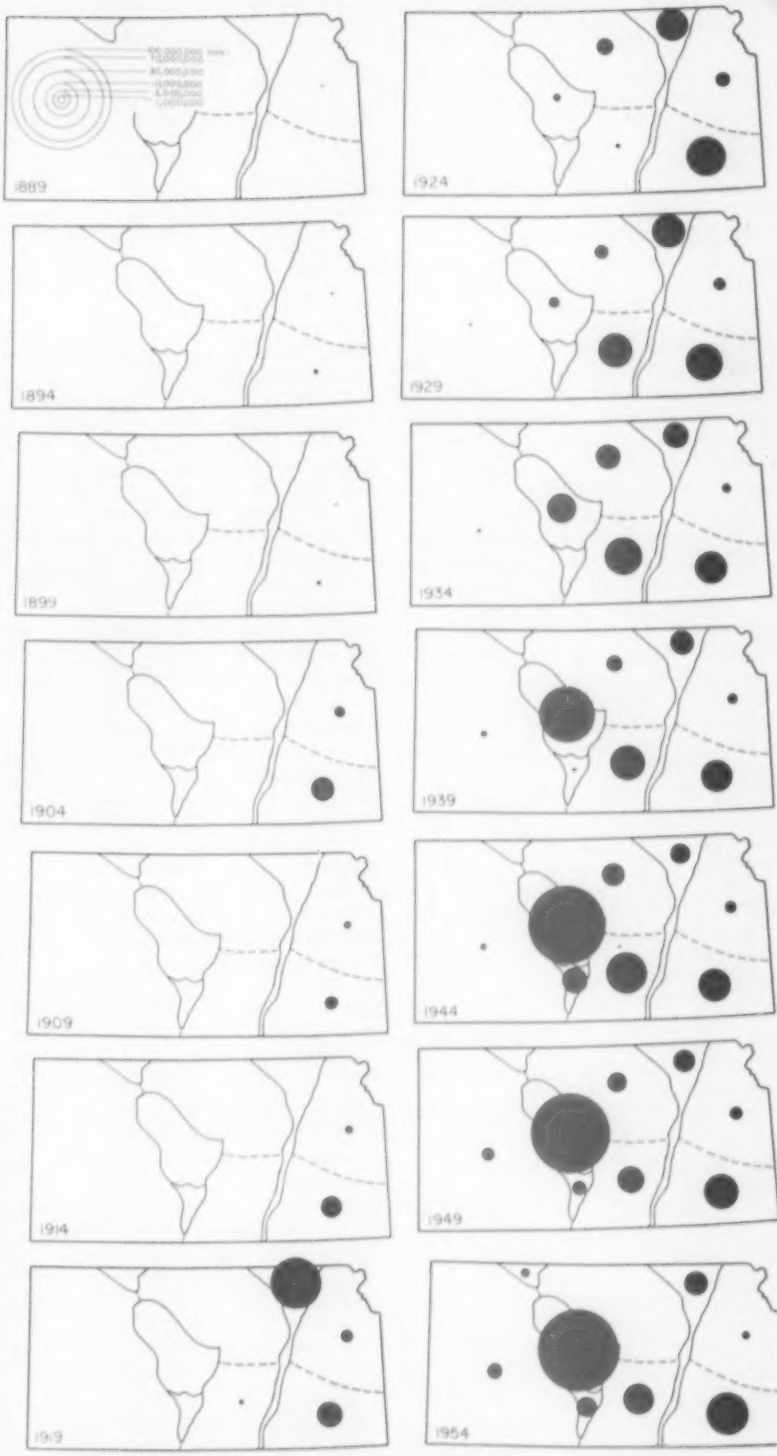
Quaternary rocks . . . Beds of Quaternary age, for the most part, are confined to the present drainage systems and are relatively thin. They consist of sand, gravel, silt, and clay. The northeastern part of the state is covered by Pleistocene glacial deposits.

Igneous rocks . . . Igneous rocks crop out at seven localities in Kansas. Five of these are in Riley County and two in Woodson County. All of the rock is basic, probably peridotite, except one granite outcrop in Woodson County. All of these intrusions are probably post-Paleozoic in age. Although minor in area, they are important in understanding the tectonic history of Kansas, and as yet no one has ventured an acceptable theory of their relation to other structural features in the state.

Structural Provinces

Parts of seven major structural units in the Mid-Continent region are present in Kansas as well as two units that are contained entirely within the state's boundaries. Four of these major structures are uparched areas that separate downwarped basins and serve to delimit them. The basinal areas are larger in areal extent than the uparched areas by a ratio of about 6:1 and likewise their volume of sediment is larger. The Hugoton embayment, for example, extends over about one-fourth of the whole state. These structural elements, which are depicted in Fig. 1, were formed in post-Mississippian time and have remained almost unchanged. For the most part these provinces are not revealed in beds younger than Paleozoic in age.

Forest City basin . . . Most of the Forest City basin is located in the adjacent states of Iowa, Missouri, and Nebraska, and only the extreme southwestern corner lies in Kansas. This basin is bounded on the west by the Nemaha anticline and on the southwest by the low indistinct Bourbon arch. The axis of the basin trends slightly east of north and lies close to and paralleling the axis of the Nemaha anticline. The position of the basinal axis near



KANSAS HAS RANKED among the top six oil-producing states for the past 38 years. Here the production from each structural province is shown at 50-year intervals. Fig. 10.

the Nemaha gives the basin an asymmetrical profile with a steep west flank and a gentle east flank. Mississippian and older strata are sharply upturned, truncated, and overstepped by Pennsylvanian sediments on the west side of the basin along the Nemaha anticline. The present basin has been a depositional area since post-Arbuckle time, first as part of the older North Kansas basin, then as a separate feature. It was not until after Mississippian time

TABLE 1—OIL AND GAS PRODUCTION FROM KANSAS' STRUCTURAL FEATURES

	Total oil prod. in bbl.	Total gas prod. in M.c.f.	Total acreage
Forest City basin	44,302,000	*72,000,000	7,056,490
Cherokee basin	551,229,000	*827,663,000	6,330,900
Nemaha anticline	351,250,000	*5,774,000	2,509,810
Salina basin	112,926,000	8,966,000	8,125,380
Sedgwick basin	308,658,000	260,279,000	5,259,740
Cambridge arch	755,000	0	693,640
Central Kansas uplift	1,105,232,000	56,435,000	3,657,350
Pratt anticline	29,686,000	31,389,000	649,650
Hugoton embayment	16,835,000	3,152,534,000	18,269,360
Total	2,520,873,000	4,415,040,000	52,552,320

*Based partly on estimates.

that the Forest City basin came into being as known today. During early Pennsylvanian time the basin derived sediments from the low chain of hills of the Nemaha granite ridge. Lee and others (1946) have discussed the geology of the Forest City basin.

Although Kansas' first oil well is credited to Miami County in the Forest City basin, the recorded cumulative oil production from the basin amounts to less than 50,000,000 bbl. or about 2 per cent of the total Kansas has produced (Table 1). Oil production at 5-year intervals, Fig. 10, for the basin since 1889 shows the first peak to have been reached in 1929 at approximately 1,600,000 bbl. and the second, about 2,400,000 in 1954, owing to the development of additional producing zones and the success of secondary-recovery projects in partly depleted reservoirs.

The principal producing beds are shallow Pennsylvanian sands. The Paola-Rantoul area of Franklin and Miami counties is the only field that has a recorded cumulative production exceeding 10,000,000 bbl. of oil (Fig. 12). Producers are still pumping stripper wells and secondary recovery projects in the field for more than 1,000,000 bbl. of oil a year (Fig. 11).

The large number of known producing zones in the basin include Douglas sands, Lansing-Kansas City, Marmaton, Cherokee, and Mississippian-derived "chat," all of Pennsylvanian age. Pre-Pennsylvanian producing zones include the Hunton, Viola, and Simpson rocks.

Along the western side of the basin adjacent to the Nemaha anticline in Morris County, Mississippian chat produces oil. What seem to be significant new reserves of oil from the Viola limestone of Morris County have been brought in with the recent discovery of John Creek field. The new field is along the trend of Davis Ranch field to the north. Davis Ranch field, which caused considerable play in the basin in 1949, also produces from the Viola limestone. Adjacent to the Paola-Rantoul area, important production is obtained from the shallow "shoestring sands" of Anderson and Linn counties. Some Mississippian chat production is also known here.

Minor amounts of crude oil have been produced from Pennsylvanian beds in isolated areas in the basin except for Atchison, Jackson, Osage, and Shawnee counties. McLouth gas and oil field of Leavenworth and Jefferson counties produced oil from Mississippian rocks and gas from sand at the base of the Pennsylvanian rocks (Lee and Payne, 1944).

Conservative estimates of cumulative gas production from the basin total more than 72,000,000 M.c.f. (Table 1).

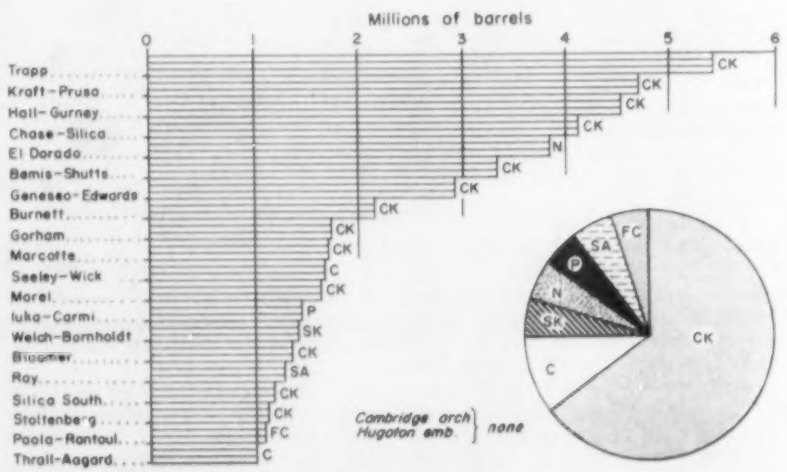
Bourbon arch . . . The Bourbon arch is a low indistinct structural feature having a northwest-southeast trend (Jewett 1951, p. 110). It separates the Forest City basin on the north from the Cherokee basin on the south. Because of the ambiguity of its role in controlling trapping of oil, however, it has been shown as a province with no width (Fig. 1), and is not considered a major structural province in this paper.

Cherokee basin . . . The northwest part of the Cherokee basin occupies extreme southeastern Kansas. It is a shallow basin, which in early Pennsylvanian time developed on top of the older Chautauqua arch. It is probably more a depositional than a structural basin, although a certain amount of downwarping took place as an accommodation to the sedimentation. As in the Forest City basin, the structural axis of the Cherokee basin lies near and parallel to the Nemaha anticline making the basin asymmetrical. Over a considerable portion of the basin, the Chattanooga shale is in contact with the Arbuckle group, the intervening rocks having been eroded away. On the west flank of the basin there is truncation of the early Paleozoic beds as in the Forest City basin. During early Pennsylvanian time the Nemaha ridge supplied sediments to the Cherokee basin.

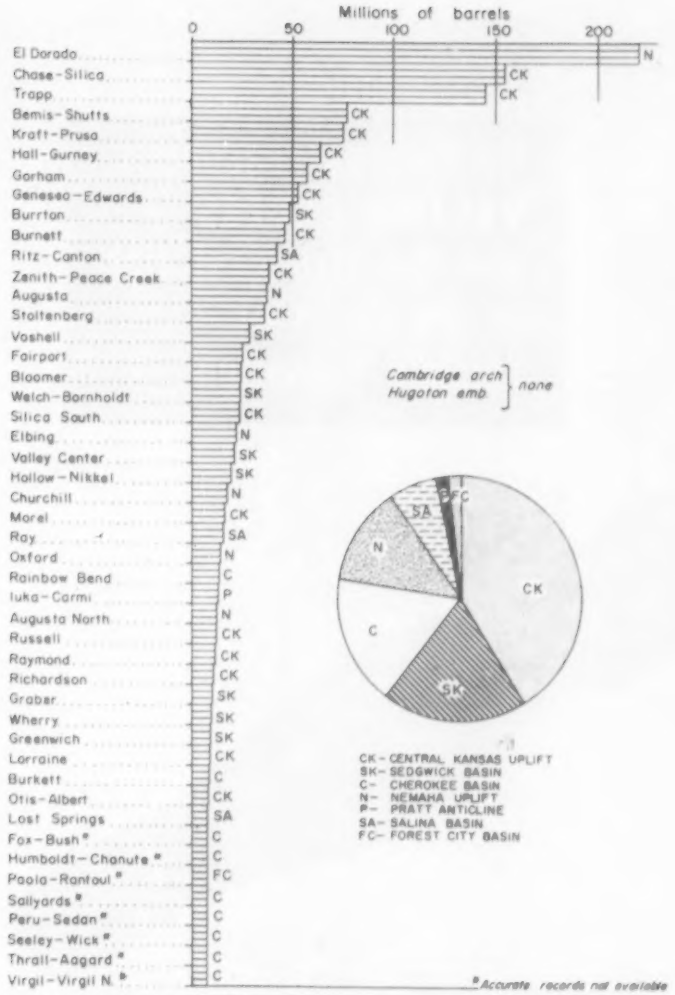
Surprisingly, the Cherokee basin, now the area of intensive pre-Pennsylvanian exploration, has the second highest cumulative oil production of any Kansas oil province, more than 550,000,000 bbl. (Table 1). Most of this oil has been obtained from shallow Pennsylvanian sands. Fig. 10 shows a peak of more than 15,000,000 bbl. of crude oil annually in the early twenties, and a second peak in 1954, when more than 18,600,000 bbl. was produced.

Only Thrall-Aagard and Seeley-Wick fields of the "Golden Lanes" of Greenwood County produced more than 1,000,000 bbl. during 1954 (Fig. 11). Production is obtained principally from the "Bartlesville" sand at a depth of about 2,000 ft. As are most of the older known Bartlesville sand fields, these are under intensive water-flooding programs. Nine fields in the Cherokee basin have cumulative oil production exceeding 10,000,000 bbl. (Fig. 12), and four of these are located on the Golden Trends in Greenwood and Butler counties.

The Bartlesville sand of the Chero-



GRAPH SHOWING OIL FIELDS in Kansas having more than 1 million barrels of production during 1954. Fig. 11.



GRAPH SHOWING KANSAS oil fields with cumulative production exceeding 10 million barrels. Fig. 12.

kee group is the best known and most prolific producing zone of the basin. It ranges in depth from less than 500 ft. in Crawford County to more than 3,000 ft. in Cowley County. According to Ver Wiebe and others (1950, Bull. 87, Pl. 3) no Bartlesville occurs in Elk and Chautauqua counties. Generally speaking, oil accumulation in the Bartlesville zone seems to be independent of structural conditions. This statement holds true for other post-Mississippian isolated sand bodies in the province.

Mississippian production is known from several areas. Among these are the Winterscheid and Virgil areas of Greenwood, Woodson, and Coffey counties. Only the upper portions of the Mississippian have been productive. Some Viola and Simpson production occurs in Butler and Cowley counties along the eastern flank of the Nemaha anticline.

Isolated areas of known Arbuckle production have prompted considerable play recently in Chautauqua, Elk, and Montgomery counties. Areas of known Arbuckle production, some now inactive, in Chautauqua County are the Oliver, McAllister, Malone, Kingston, and Monett (now part of the Peru-Sedan). In Elk County, Arbuckle production has been reported from Ferguson East, Porter, Arbuckle, Fleming, Key, Liscoe, Shambaugh, and Webb fields. Areas of reported Arbuckle production in Montgomery County are Brewster, Alloway, Bellairs, Thompson, and Coleman fields. Jewett (1954) describes these areas of Arbuckle production.

Gas production in the province was first reported in 1873 from the area of Iola field in Allen County. Most of the gas has been produced from Pennsylvanian sands. Conservative estimates of cumulative gas production total more than 800,000,000 M.c.f. (Table 1).

Nemaha anticline . . . The Nemaha anticline trends northeast-southwest completely across Kansas. It continues north into Nebraska, where it is called the Table Rock anticline, and south into Oklahoma to the vicinity of Oklahoma City. The narrow anticline separates the Forest City and Cherokee basins on the east from the Salina and Sedgwick basins on the west. The pre-Cambrian core or the granite ridge of the anticline comes within about 700 ft. of the surface near the Kansas-Nebraska line, but plunges south, so that on the Oklahoma-Kansas line it is about 4,000 ft. below the surface. The granite core of the anticline is characterized by a series of crystalline knobs along the crest of the structure. The configuration of the pre-Cambrian surface in eastern Kansas is shown by Jewett (1954, p. 58). On both sides of the uparched area, pre-Pennsylvanian strata have been upturned, truncated, and overstepped.

Anticline Is Faulted

Farther south along the ridge, near the Kansas-Oklahoma border, however, the deformation is of less magnitude and sharpness, and the Paleozoic beds are folded over the crest. The anticline is faulted along the east side in several areas. In post-Mississippian-pre-Pennsylvanian time the Nemaha anticline was uplifted, divided the North Kansas basin, and formed the western limit of the Forest City basin and the eastern side of the Salina basin. Beds as young as Permian are arched over the structure, implying later movement.

The Nemaha anticline oil province contains the early giant in Kansas oil production. Cumulative oil production (Table 1) totals more than 350,000,000 bbl. The peak production from the province came in 1919 when more than 23,000,000 bbl. of crude oil was produced, which was much more than the market could stand at the time. Six fields in the oil province have cumulative production exceeding 10,000,000 bbl. Of course, El Dorado field of Butler County leads the entire state with more than 220,000,000 bbl. cumulative production. Others in the province are the Augusta with more than 35,000,000, and Elbing, Churchill, and Oxford fields with more than 15,000,000 bbl. cumulative production each. Recorded production from Augusta North field totals just slightly less than 15,000,000 bbl. El Dorado field is the only field in the province that produced more than 1,000,000 bbl. of oil during 1954; crude oil from that field totaled more than 3,800,000 bbl. that year.

The Arbuckle dolomite has been the most prolific producing zone in the province, and lesser production has been

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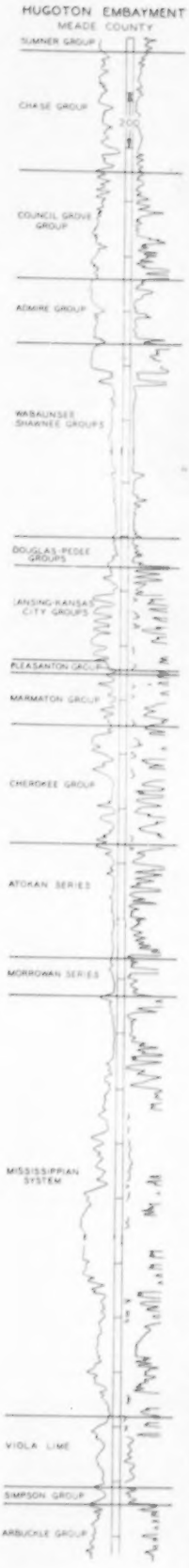

UNTIL recent years, the primary target in the Hugoton embayment was the Chase group that produces gas in the huge Hugoton gas area. This embayment offers the most complete section of potential oil or gas-bearing rocks in the state. Fig. 13.

Kansas Exploration

found in the Simpson, Viola, Hunton, and Mississippian rocks. There has been considerable production from shallow Pennsylvanian sands, and from limestones of the Lansing-Kansas City group.

Areally, most of the production in the province comes from Marion, Butler, Cowley, and Sumner counties. Minor amounts of Hunton production are known in Nemaha County, along the northern border of the state.

Gas production from the province is not significant. Much of the gas produced has been used in field operations.

Salina basin . . . Only the southern tip of the Salina basin extends into Kansas. By far the greater part of this structural unit lies in Central Nebraska. The east edge of the basin is bounded by the Nemaha anticline; the west side is limited by the Cambridge arch; the southwest flank is outlined by the Central Kansas uplift. This is the second largest synclinal basin in Kansas. The axis of the basin trends northwest-southeast and plunges north toward the deeper part of the basin in Central Nebraska. Pre-Pennsylvanian strata are upturned, truncated, and overstepped around part of the southern perimeter of the basin. Sediments increase in thickness toward the center of the basin. The southern end is separated from the Sedgwick basin arbitrarily along an east-west pre-Chattanooga valley. Lee and others (1948) described the stratigraphy and structural development of the basin.

Kansas' second-largest basin has been little explored for its oil and gas possibilities. Cumulative oil production is only slightly more than 100,000,000 bbl., and gas production is not of major importance. Only the Lost Springs area, which is very close to the Nemaha province, and Ritz-Canton field, which lies adjacent to the arbitrarily drawn southern boundary of the province, and Ray field adjacent to the Cambridge arch, have cumulative production exceeding 10,000,000 bbl. of oil. Ray field is the only field in the basin that produced more than 1,000,000 bbl. during 1954 (Fig. 11).

Producing zones include the Arbuckle, Simpson, Viola, Maquoketa, Mississippian, and Lansing-Kansas City rocks. Probably the most prolific producing zones, discounting the Arbuckle in Ray field, are the Viola and Mississippian rocks.

Few counties in the Salina basin have had oil and gas discovered within their boundaries. These are Phillips, Rooks, Osborne, Morris, Dickinson, Marion, Saline, and McPherson counties.

Sedgwick basin . . . The Sedgwick basin, located in South Central Kansas, is a northern shelflike extension of the Anadarko basin into Kansas. This basin or embayment is roughly symmetrical and plunges southward. It is bounded on the east by the Nemaha anticline and on the west by the Central Kansas uplift and the Pratt anticline. The northern end of the basin is indistinct and no uparched area separates it from the Salina basin. The strata in the basin are characterized by facies change and increased thickness southward from the shelf area into the deeper part of the Anadarko basin proper.

Although prolific oil fields have been known for some time in the Sedgwick basin, just in the last few years has exploration discovered additional large reserves of crude oil. Cumulative oil production from the province amounts to slightly more than 308,000,000 bbl., and gas production to about 250,000,000 M.c.f. (Table 1). Peak oil production as shown by selected 5-year intervals was reached in the early 1930's. Burrton field with more than 45,000,000 bbl., Voshell with about 30,000,000 bbl., Welch-Bornholdt with about 25,000,000 bbl., and Valley Center and Hollow-Nikkel fields with slightly more than 20,000,000 bbl. cumulative oil production are the large developed areas in the basin. Other significant fields in the province, each with more than 10,000,000 bbl. cumulative production, are Graber, Wherry, and Greenwich fields (Fig. 12). Only Welch-Bornholdt field produced more than 1,000,000 bbl. of oil during 1954.

The known producing zones in the basin include the Arbuckle, Simpson, Viola, Hunton, Mississippian, Cherokee sands, and the Lansing-Kansas City ed that the state's chief prolific "Hunrocks. Jewett and Smith (1949) reportton" fields were located in the basin. With the success of the Gladys, Grabs, Spivey, and Rhodes Mississippian fields, it might properly be said that the Mississippian is now the most prolific producing zone and gives promise of containing the largest reserves.

Gas in large amounts is found only in Mississippian rocks, and Mississippian gas production has been found in most of the counties in the basin. Peak production as shown in 5-year intervals occurred during the war years of the early 40's.

Central Kansas uplift . . . The Central Kansas uplift is the dominant structural feature of Central Kansas. The uplift separates the Salina basin on the east from the Hugoton embayment on

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the west. Before the formation of the Cherokee basin the uplift continued to the southeast and connected with the axis of the old Chautauqua arch. Along the crest and flanks of the uplift are several minor structures, which differ in trend from the uplift itself. Pre-Cambrian rocks are overlain by Pennsylvanian sediments, and on the flanks pre-Pennsylvanian sediments are upturned, truncated, and overstepped by Pennsylvanian beds. A good description of these buried Precambrian hills of the uplift is given by Walters (1946). The geology of the uplift is described by Koester (1935) and Lee (1953).

The Central Kansas uplift is the most prolific oil province in Kansas. Up to 1955, more than 1,100,000,000 bbl. of oil or 44 per cent of the state's total cumulative production had been produced from the limited section of rocks in the province. The most prolific producing zone is the Arbuckle.

During 1954, Trapp, Kraft-Prusa, Hall-Gurney, and Chase-Silica fields produced more than 4,000,000 bbl. of crude oil each. Bemis-Shutts, Geneseo-Edwards, and Burnett fields each produced more than 2,000,000 bbl. of oil during 1954. Gorham, Mareotte, Morel, Bloomer, Silica South, and Stoltenberg reported annual production during 1954 of more than 1,000,000 bbl. of oil (Fig. 11).

Chase-Silica and Trapp fields on the Central Kansas uplift have cumulative production of about 150,000,000 bbl. of oil. Thirteen fields in the area have cumulative production of more than 20,000,000 bbl. Six other fields have cumulative figures exceeding 10,000,000 bbl. (Fig. 12).

Production is obtained from the Douglas, Lansing-Kansas City, Pennsylvanian basal conglomerate, Simpson, Arbuckle, Reagan, and pre-Cambrian rocks. Orth field of Rice County is exceptional in producing both oil and gas from a pre-Cambrian reservoir.

Cambridge arch . . . The Cambridge arch is a large anticlinal feature located in Nebraska and Kansas. It is elongated in a northwest-southeast direction on the same trend as the Central Kansas uplift and the Chadron arch of Nebraska. The trend forms an arcuate chain of uparched features convex to the southwest. A low structural saddle separates the Cambridge arch from the Central Kansas uplift. On the crest of the structure, pre-Cambrian rocks are overlain by strata of Pennsylvanian age; older Paleozoic rocks are upturned, truncated, and overstepped on the flanks. The arch is flanked by several smaller paralleling anticlinal and synclinal structures. The tectonic history of the arch was described by Merriam and Atkinson (1955). The configuration of the pre-Cambrian surface on the arch in Kansas is shown by Merriam and Goebel (1954).

The Cambridge arch is a newly delineated structural feature of Kansas, including most of Norton County, and parts of Decatur and Phillips counties. Oil was discovered in the Province in 1953, with the successful completion of the discovery well of Norton field. Production is principally from the Arbuckle rocks, but some is reported from the underlying Reagan sandstone.

Pratt anticline . . . This feature is a large, broad, southward-plunging nose. It separates the Sedgwick basin on the east from the Hugoton embayment on the west. Farther south in Oklahoma the structure dies out and there is no distinction between the Sedgwick basin and the Hugoton embayment on the northeastern flank of the Anadarko basin. On the crest of the anticline is a large area where the Mississippian rocks are absent and Pennsylvanian beds overlie the Viola formation.

A total of somewhat more than 29,000,000 bbl. of oil has been withdrawn from the oil province known as the Pratt anticline. Peak production was reached in the late war years, when more than 5,000,000 bbl. of oil was reported. Slightly more than 31,000,000 M.c.f. of gas has been produced from the province, peak production coming before 1940.

Only Iuka-Carmi field is among the 1,000,000-bbl.-annual-production class, and only that field has a cumulative production exceeding 10,000,000 bbl.

The principal oil-producing zone of prorated Iuka-Carmi field is the Simpson formation. Other known producing zones in the field are the Lansing-Kansas City, Mississippian, Viola, and Arbuckle rocks. These are essentially the known producing zones for the entire province. Considerable gas production has come from the Viola, Simpson, and Mississippian rocks.

Hugoton embayment . . . The Hugoton embayment is a northern shelf-like extension of the larger Anadarko basin of Oklahoma (Merriam, 1955). The embayment extends over parts of Kansas, Colorado, Texas, and Oklahoma. The eastern edge of the structure is bounded by the Pratt anticline, the Central Kansas uplift, and the Cambridge arch. The western limit is formed by the Las Animas arch. It plunges south and the sediments thicken both toward the axis of the embayment and south into the Anadarko basin. The embayment is developed mainly in Paleozoic rocks and is not expressed in Mesozoic and Tertiary beds. In Mesozoic time the Western Kansas basin developed in the area of the Hugoton embayment; post-Mesozoic development consisted of epeirogenic movements tilting the area eastward. These movements did not alter the shape of the embayment, however. Facies and thickness changes occur southward from the shelflike area to the geosynclinal conditions in the Anadarko basin. The development and form of the embayment, thus, was dependent on conditions that existed throughout the geologic history of the Anadarko basin.

In Kansas, the Hugoton embayment offers the most complete section of possible oil-bearing rocks (Fig. 13), is the largest province, and has the least number of exploratory tests within its boundaries. The province contains no field producing 1,000,000 bbl. of oil per year, nor has it any fields with 10,000,000 bbl. production.

The big production in the province has been the gas from its namesake, Hugoton gas field of which more than 50 per cent lies within Kansas. By definition, the gas production from the Hugoton gas area, which was discovered in 1922, is entirely from the Chase group of Permian age. The reported production from the field during 1939 was more than 50,000,000 M.c.f., and in 1954 the production exceeded 380,000,000 M.c.f. Cumulative production from the Kansas portion of the embayment amounts to more than 3,000,000,000 M.c.f. of gas. The Chase group of rocks in the Hugoton gas area is found at depths of about 2,600 to 2,950 ft. below the surface. The reservoir of the Hugoton gas area is a stratigraphic trap that is due to the irregular distribution of porosity in dolomitic limestones along their strike. The westward limit of production seems to be the zone of marine and nonmarine interfingering (Moore and Jewett, 1942).

Additional gas reserves have been discovered within the province in recent years. Of special significance among these are the Greenwood gas area, which by definition includes only production from Lansing-Kansas City and younger Pennsylvanian rocks. Morrowan gas production from Boehm, Richfield, Adams Ranch, Liberal-Light, Liberal Southeast, and Thirty-One fields is significant. Mississippian gas production is important in the province. The large McKinney field in Clark and Meade counties is perhaps the best example, and its discovery led to the development of other new Mississippian gas fields in Kiowa and Edwards counties.

Oil production was first reported from Aldrich field of Ness County in 1929. Since that time, somewhat less

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than 17,000,000 bbl. of crude oil has been produced. Peak oil production was reached in 1954. Novinger field of Meade County (Morrowan production) will perhaps be the first field in the province to reach the 10,000,000-bbl. cumulative figure.

Oil reservoirs are known to exist in Topeka, Lansing-Kansas City, Marmaton, Pennsylvanian basal conglomerate, Cherokee, Morrowan, Mississippian, Viola, and Arbuckle rocks in the province. The location of the producing fields, and depths to these zones are given in Ver Weibe and others (1955).

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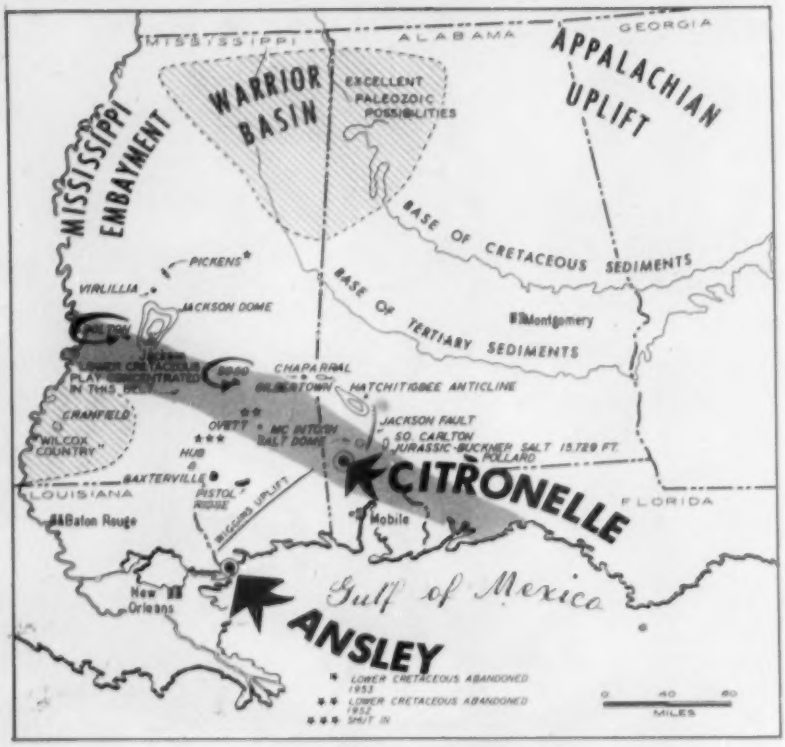
ALTHOUGH Lower Cretaceous exploration has been concentrated in a fairly narrow belt that extends from Bolton to Citronelle, recent production at Ansley and Pistol Ridge-Maxie has expanded the area of interest. Fig. 1.



Deep South Ready for Deep Payoff

Here's why oil hunters regard the Lower Cretaceous beds in southeastern U. S. as attractive targets for the drill

by Norman S. Morrisey
Drilling-Development Editor

STRAWS tossed into the air show which way the wind is blowing. And Citronelle, Ansley, and Bolton and the indicated Dantzler production at Maxie-Pistol Ridge are all straws in the wind. They forecast a favorable exploration climate for the southeastern United States. What is more important, these recent discoveries emphasize the oil potential of the Lower Cretaceous rocks of Mississippi and Alabama and what may be expected in northern Florida.

The economic value of the Lower Cretaceous reservoirs of the southeastern United States has long been recognized. But it has only been within the past few years that oil companies have been able to transform this theory into producing fields. Structure alone is not enough. Companies have learned that simply drilling an attractive seismic anomaly is not the answer. Knowledge of regional and local geology is a prerequisite to successful exploration. Detailed stratigraphic studies are every bit as important as a good set of seismic maps. But armed with these prerequisites, companies are combing Mississippi. This seismic effort is only the forerunner of a series of undiscovered oil fields that may well overshadow Tinsley, Pickens, and Baxterville.

Why is the area arousing such interest? A quick comparison between North Louisiana and Mississippi provides an answer. In North Louisiana over 100 fields produce from beds of Lower Cretaceous age or older. There is excellent evidence to show that these producing formations extend southeast and are present in Mississippi and Alabama. Yet these two states have only a handful of Lower Cretaceous fields. Because the general geology of the two areas is so similar, oil companies expect eventually to find many new fields that will produce from the older rocks.

Actually the Lower Cretaceous rocks in the southeastern United States are very much of an unknown quantity. Until recently the main targets were the Wilcox, Eutaw, and Tuscaloosa formations. Even today the number of wells that have entered Lower Cretaceous rocks is considerable less than one deep test per township.

Geologists point to Soso, discovered in 1953, as an example of what can be expected from the Lower Cretaceous reservoirs. The zones at Soso put out nearly 11,000 bbl. of oil per day from 3,000 producing acres. Citronelle, producing from Rodessa sands, was discovered late in 1955 and now has 4,000 acres that are considered potentially productive. Many top exploration geologists class Citronelle as the most important discovery in the United States during 1955 because of its Lower Cretaceous production.

Pay Zones

The majority of the fields in southeastern United States produce from the Wilcox sands. The Eutaw and Tuscaloosa formations account for only 29 per cent of the total number of producing fields, and produce 60 per cent of the oil.

Wilcox . . . Independent operators concentrate on the Wilcox trend where production is from lenticular sands in this Eocene formation. Most of the activity lies in western Mississippi, principally in Jefferson, Franklin, Adams, and Wilkinson counties. The trend continues west into Louisiana where the "Wilcox country" covers La-Salle, Catahoula, Concordia, and Tensas parishes.

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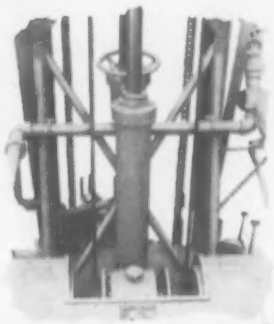

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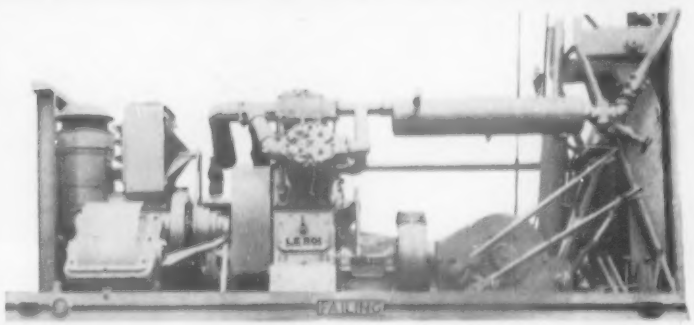

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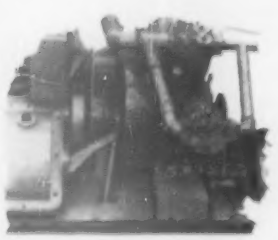

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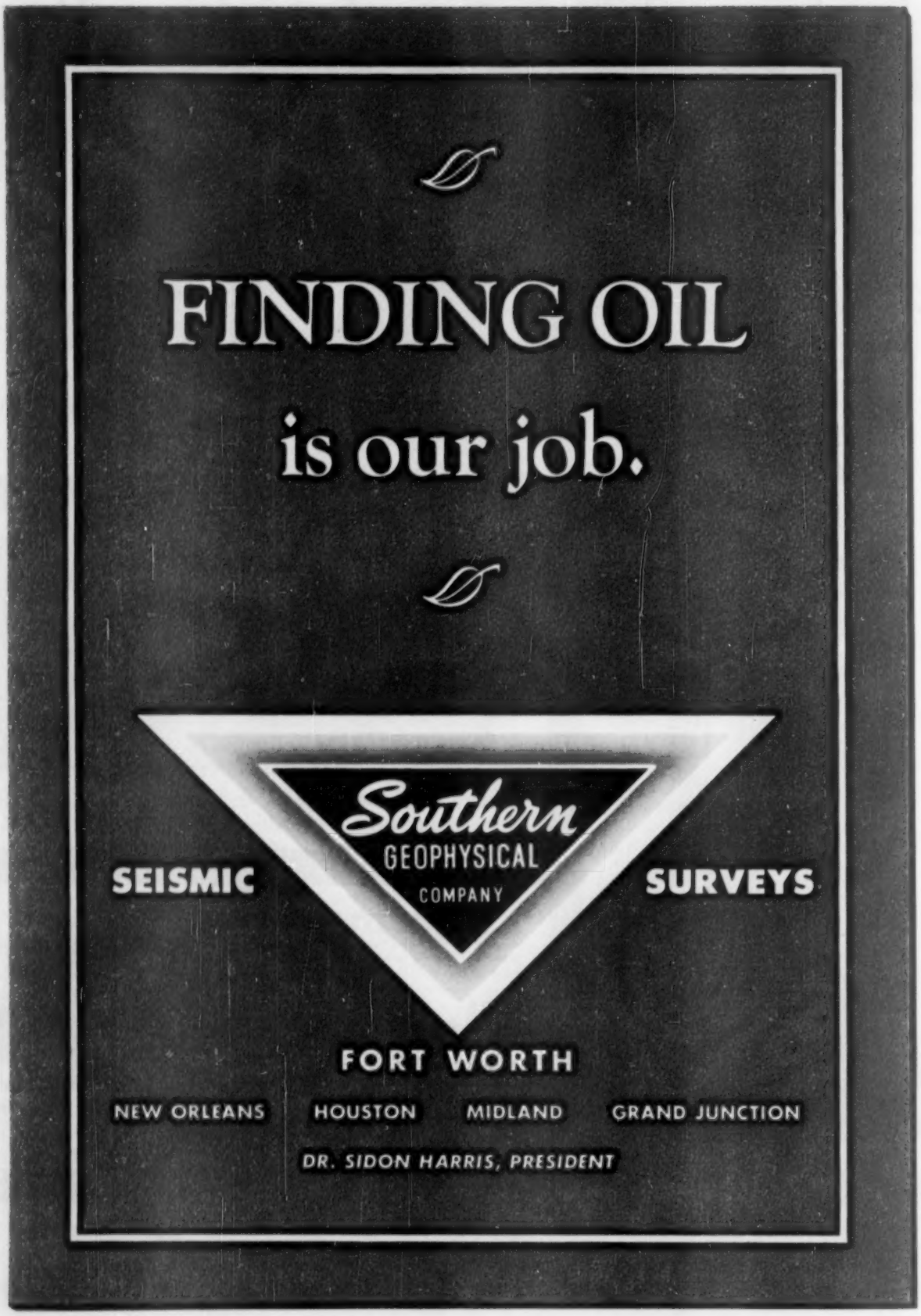
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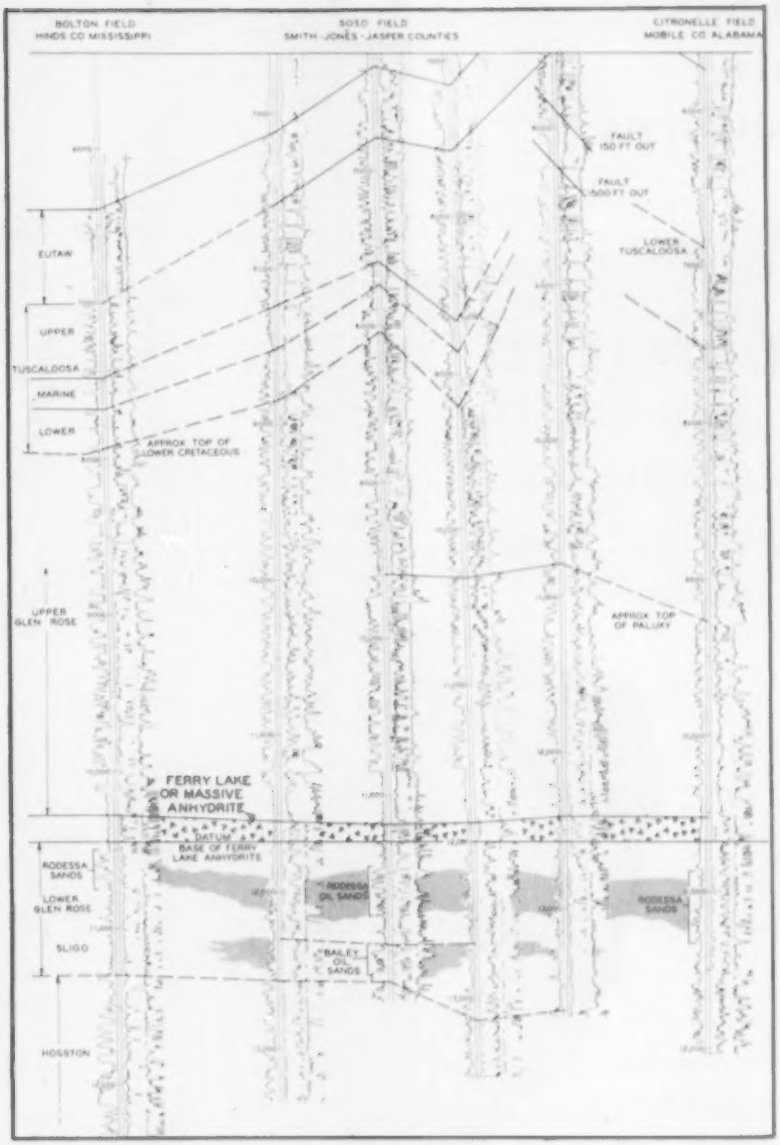

STRATIGRAPHIC CROSS-SECTION from Bolton to Citronelle reveals that the Massive or Ferry Lake anhydrite is the most persistent subsurface mapping unit. Updip to the northeast, the anhydrite zone grades into a clastic facies and is very difficult to recognize. Fig. 2.

Typically, Wilcox fields are small in area, covering less than a section. Only 13 of the 97 Wilcox pools in Mississippi have more than 10 producing wells, and one and two-well fields are common. Generally speaking, the producing sands are erratic and production is controlled by either structure or stratigraphy or a combination of both.

Eutaw . . . Sands in this zone produce in 24 pools in Mississippi and three fields account for about two-thirds of all the oil currently taken from the Eutaw — Heidelberg, Eucutta, and Pickens. There is some Eutaw production in Alabama at Gilbertown.

Tuscaloosa . . . By far the most important producing formation to date in southeastern United States is the Tuscaloosa (Fig. 2). These sands produce from the Mississippi-Louisiana line eastward to Pollard field in Alabama. The Tuscaloosa is the basal formation of the Upper Cretaceous and is correlative with the Woodbine sand of East Texas.

The Tuscaloosa consists of two recognizable formations, the upper and the lower. Within the lower Tuscaloosa are three units, the basal "Massive sand section," the "Marine section," and the "shale and sand section." McGlothlin ("General Geology of Mississippi," A.A.P.G. Bull., January 1944, page 40) considers that there is a major unconformity separating the upper and lower Tuscaloosa.

Most of the oil comes from the lower Tuscaloosa sands, particularly the basal Massive sand. At Mallalieu the Massive sand has an average porosity of 30 per cent and the permeability averages about 1,500 md. At Brookhaven, the Smith zone or basal Tuscaloosa sand is 90 ft. thick and has an average porosity of 26 per cent and an average permeability of 340 md.

Lower Cretaceous Production

The deeper pay zones may well contain the cream of production in the southeastern United States. Several different formations already produce (Fig. 3) and more will be added to the producing column as time goes on. Very little is known about the reserves of the Lower Cretaceous reservoirs because of the small number of producing fields and newness of production. To date, zones in the Dantzler, Washita-Fredericksburg, Paluxy, Rodessa, Sligo, and Hosston produce. The Mooringsport, Hosston, Cotton Valley, and Smackover is not as attractive a target in Mississippi and Alabama as it is in North Louisiana. Where the Smackover becomes a sandstone, the zone should be an effective reservoir.

Bolton . . . The principal Paluxy field is Bolton, discovered in 1954. Bolton has not lived up to early expectation and today has a daily output in the neighborhood of 1,500 bbl. from 20 wells. Recently operators have found Rodessa production and the new zones should improve the reserve picture at Bolton considerably.

Bolton is an elongate anticlinal closure on the downthrown side of a fault zone. The faulting occurs along the northeast side of the field and trends northwest-southeast. Some geologists consider that the present Bolton production is located in the graben of a deep-seated salt dome; they anticipate additional production to the southwest of the present field if the companion fault is present.

Ansley . . . Ansley is the most recent Lower Cretaceous discovery and the most significant Washita-Fredericksburg production in the state. The field is too young to be evaluated with any degree of accuracy, but oil geologists recognize its importance. The discovery well, Marshall R. Young 1 Cuevas Heirs (30-9s-15w, Hancock County), had an initial potential of 195 bbl. of oil and 1.7 million cubic feet of gas per day. The Ansley discovery is important for several reasons: (1) it opened a new pay zone for Mississippi; (2)

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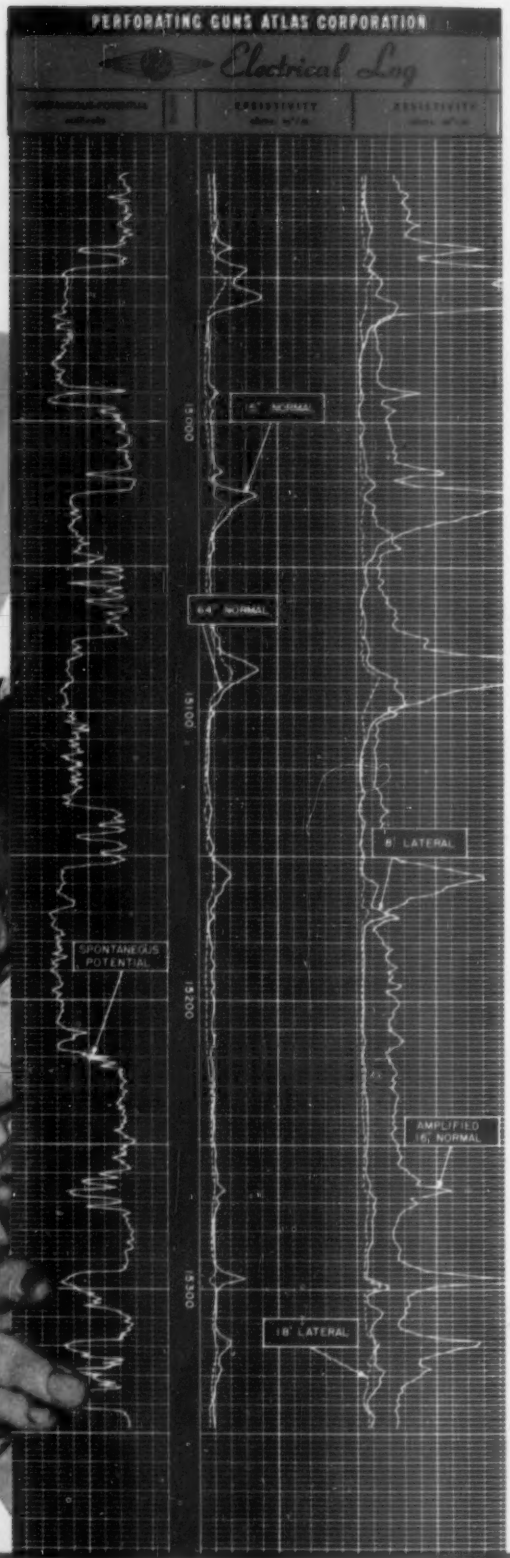

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it is located on a positive feature that is probably related to the Wiggins arch; (3) there are excellent possibilities of finding strat traps in the area since the 1 Cuevas Heirs went from Heterostegina-Oligocene into Wilcox-Eocene, missing the Frio-Vicksburg and Jackson and Claiborne (upper Eocene) sections.

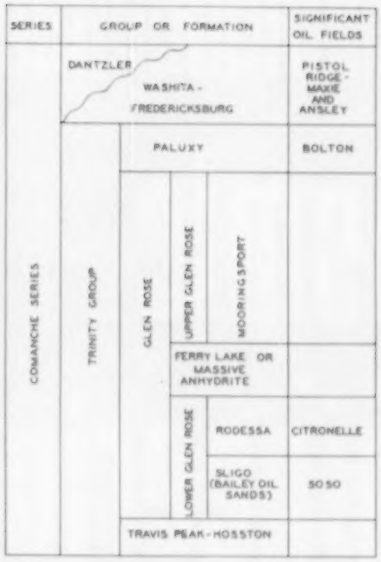
Citronelle . . . The most closely watched oil field in southeastern United States is Citronelle that lies only 40 miles northwest of Mobile, Ala. Production is from lenticular sands in the Rodessa at 11,400 ft.; the structure itself is a large anticline. Limited data indicate that a least 4,000 acres are proved or semiproved. Operators are faced with a serious problem in developing Citronelle production. The erratic sands and low pressures have already forced the operators to complete some wells on the pump.

Soso . . . Undoubtedly the most important Lower Cretaceous field in southeastern United States to date is Soso. Two zones combine to produce 10,560 bbl. of oil daily. The Rodessa zone at 11,500 ft. has only 3 wells, but the deeper Sligo sand, the Bailey, has 68 wells and produces 10,150 bbl. daily.

Soso is a fairly simple anticline (Fig. 4) that covers some 3,000 acres and has several pay zones. Two sands in the Eutaw are gas-bearing, but the principal oil reserves lie in the Bailey sand; this is part of the Sligo formation that produces in East Texas and North Louisiana. In addition, Paluxy sands are oil-bearing.

Exploration

Oil companies are relying heavily on seismic crews to locate new oil fields in Mississippi and Alabama. Baxterville, Brookhaven, and many of the other large producing fields were originally located on gravity surveys. The gravity anomaly apparently is the result of salt movement because several fields overlie deep-seated salt domes. Most of these gravity anomalies have been tested and oil companies now are using seismic surveys for both reconnaissance and detail.



OIL PRODUCTION has been established or indicated in nearly all the Lower Cretaceous formations. Fig. 3.

Actually rock facies is as important as structure. The lithology varies rapidly up and downdip, although along strike it is fairly consistent in character (Fig. 2). Updip the beds grade into a continental facies in which oil possibilities are poor. Too far downdip the same section changes from a sand sequence into barren limestones and shales.

The best possibilities for production apparently lie in a narrow belt where the continental and marine facies interfinger or where marine sands were deposited. The geological situation in Mississippi and Alabama can be compared to the Cotton Valley section in North Louisiana. Updip in Arkansas the formation is predominantly continental clastics with only erratic production. Downdip the section grades into a marine facies with the familiar blanket sands, the "D," Bodcaw, and Vaughan; these sands produce in a narrow strip 100 miles long, but only 10 miles wide. Further downdip, the section grades into an essentially barren facies. Some of the Lower Cretaceous formations in Alabama and Mississippi will undoubtedly have similar production pattern.

Geologists are handicapped by the lack of persistent recognizable mapping units and scarcity of well control. The most reliable Lower Cretaceous mapping horizon is the Ferry Lake or Massive anhydrite. Updip, however, this zone, too, grades into a clastic facies and becomes unrecognizable. Along strike the Ferry Lake can be traced for miles and is an excellent mapping horizon (Fig. 2). Depth to the producing zones is another serious problem, both from an economic aspect and from a seismologist's point of view. All the important Lower Cretaceous production comes in below 9,000 ft. and at Soso, Sligo production occurs at 12,000 ft.

Oil finders have received a welcome shot in the arm with the recent wave of Lower Cretaceous discoveries and are confident of finding more like them. They consider that Mississippi and Alabama today are in the same position North Louisiana occupied 20 or 30 years ago before the discovery of Lower Cretaceous production.

Geology

Mississippi and Alabama lie on the east limb of the Gulf Coast geosyncline. Although the regional dip is to the south or southwest, the homocline is broken by several large features along with minor folds and faults. Largest of these features are the Jackson dome, the Wiggins arch, and the Sharkey platform. Both Ansley and Citronelle may be related to the Wiggins arch since each is located on the flanks of this uplift. Some geologists

OIL PRODUCTION BY FORMATIONS IN MISSISSIPPI

Reservoir—	No. of oil pools	Avg. daily production per field	Avg. daily production per well	Avg. daily production per formation	No. of wells
Wilcox	95	277	42	26,271	572
Selma	2				
Eutaw	24	1,110	33	22,150	677
Tuscaloosa	26	2,080	70	54,100	761
Lower Cretaceous	14	1,550	90	21,800	243

IMPORTANT LOWER CRETACEOUS OIL POOLS

Field and producing zone—	No. of oil wells	Avg. daily production (field)	Approx. depth of reservoir	Average thickness (ft.)	Average porosity (per cent)	Average permeability (md.)	Original reservoir pressure (psi.)	Discovered
Bolton—Paluxy	18	1,200±	10,000	30	18	4-167	4,627	7-20-54
Bolton—Rodessa	2		10,500					7-20-54
Citronelle—Rodessa			11,400					10-10-55
Chaparral—Lower Cretaceous	7	600	9,300	14	27.5	14.7	4,165	4- 1-52
Pistol Ridge—Lower Cretaceous	2	220						Jan. 1951
Soso—Rodessa	3	400	11,504	8	15.3	128	5,075	8-14-53
Soso—Bailey (Sligo)	68	10,150	11,980	20-50	15.7	208	5,553	8-14-53
Ansley—Washita-Fredericksburg			10,850					Dec. 1955

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consider that the Wiggins arch has been a positive feature for a long period of time. If such is the case, it may have played an important role in controlling oil accumulation on its flanks. Invariably oil is found along the flanks of ancient positive features such as the Nemaha Granite Ridge in Oklahoma and the Central uplift in Kansas. More drilling is needed in southern Mississippi and Alabama to help unravel the geologic history of the Wiggins arch.

Piercement salt domes are common in the south-central part of Mississippi, but only a few have had commercial shows of oil or gas, mostly the latter; however, many of the 40-odd piercement domes have had noncommercial oil shows. The flanks of these domes are virtually untested because the customary practice is to spot the test on the crest of the dome.

Several of the larger oil fields are deep-seated salt domes and appear as gravity anomalies. Tinsley, Gwinville, and Baxterville fall in this category. Many other fields are undoubtedly related to salt movement; the more familiar are Mallalieu, Brookhaven, Cranfield, and Carthage Point.

Soso may be related to deep-seated salt movement, possibly even a residual anticline or any early "salt fold." The structure shows thinning in the Upper Cretaceous beds, indicating growth during deposition and proving that Soso has been high since Comanche time.

A zone of normal faults and associated grabens extends from northeastern Yazoo County, Mississippi, southeastward to Gilbertown and Pollard in Alabama. This trend is very similar to the Mexia-Talco fault trend in East Texas and the South Arkansas fault trend. All these fault trends may be related. Several important oil fields are associated with the Mississippi-Alabama fault zone; among them are Pickens, Heidelberg, Eucutta, Yellow Creek, Gilbertown, and Pollard.

The Black Warrior basin lies in northern Mississippi and northwestern Alabama. Here the Upper Cretaceous rocks are in direct contact with Pennsylvanian beds. The Paleozoic structure is extremely complex with many large anticlines. Structurally the Black Warrior basin appears to be similar in southern Oklahoma. Only a limited number of gas fields produce in this basin with the Chester (?) sands as the reservoirs.

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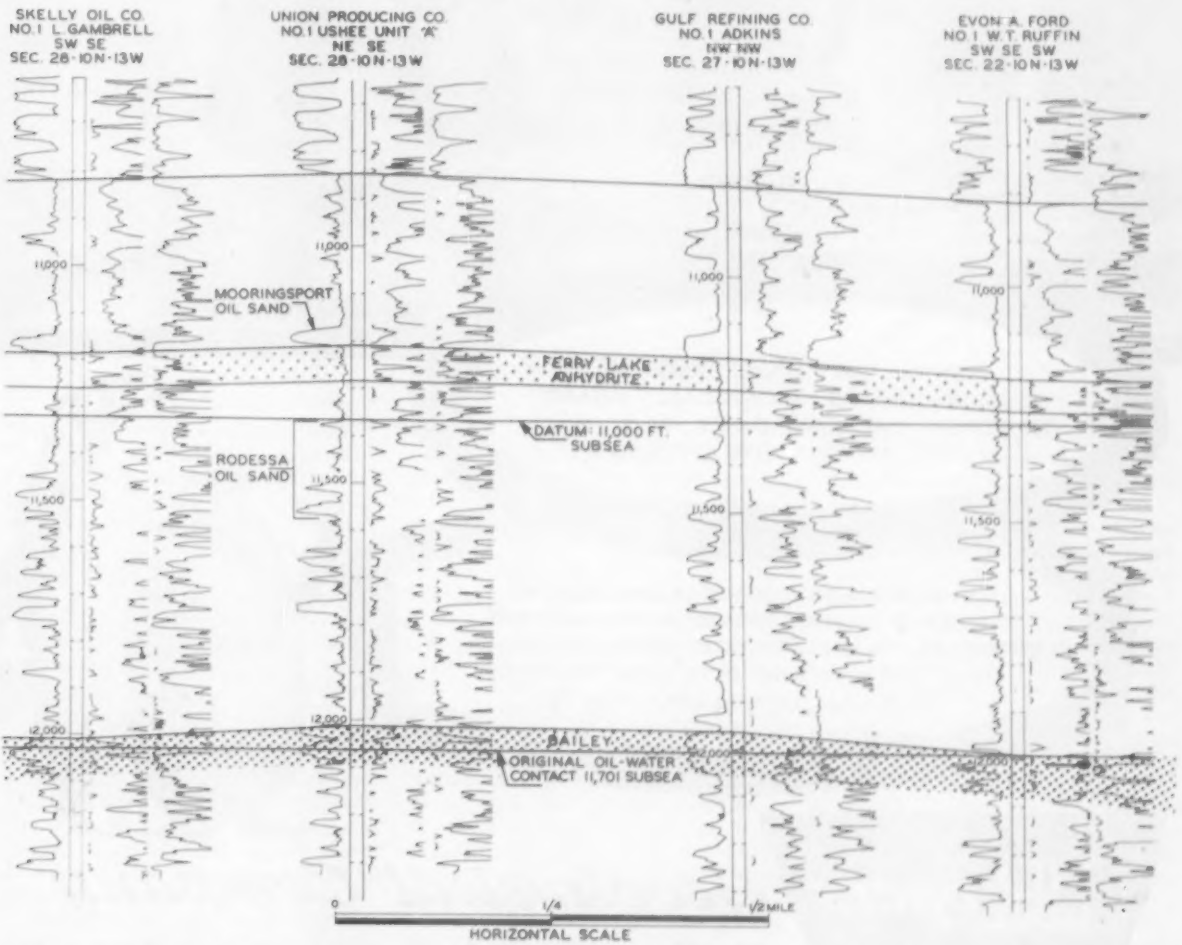

SOSO IS A LOW-RELIEF ANTICLINE with the pay zones at 12,000 ft. and would be a very difficult target to locate with seismograph. Fig. 4.

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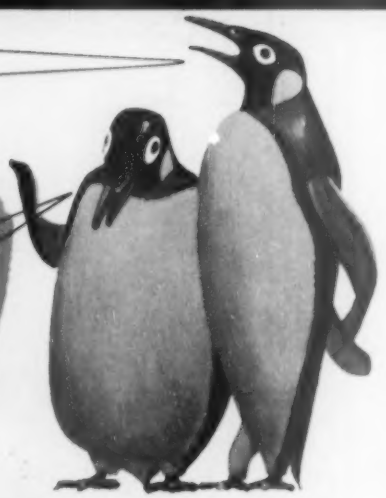

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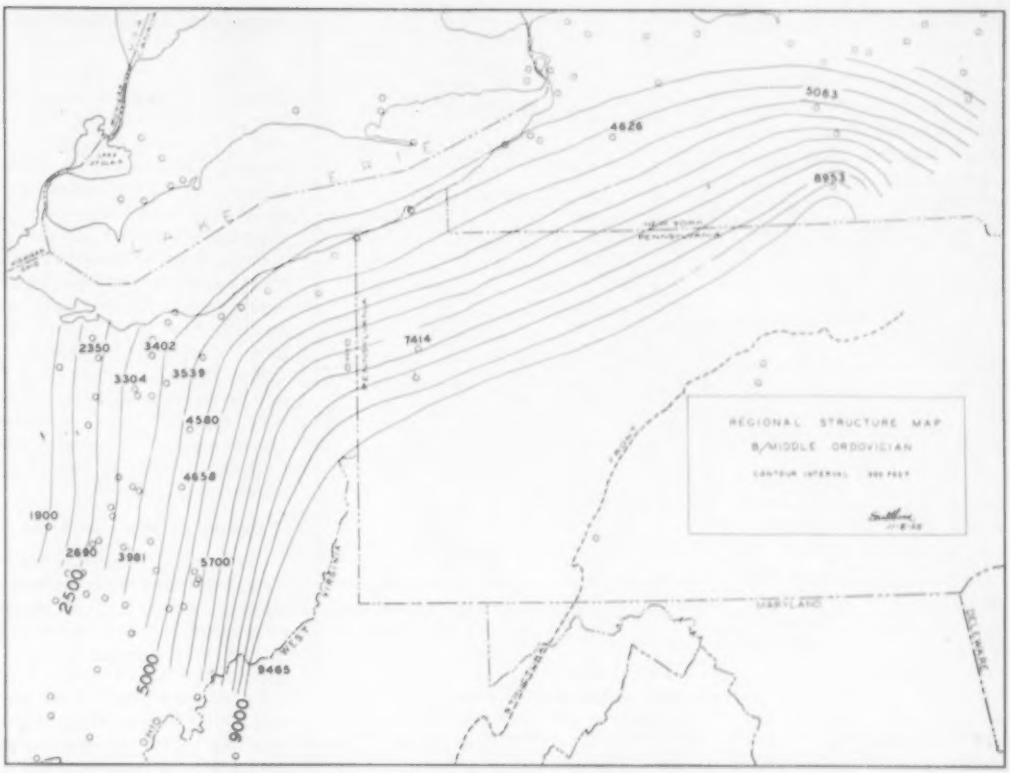


NO SIGNIFICANT LARGE REVERSALS in the regional dip have been mapped to date along the northern limb of the Appalachian basin. Fig. 1.

SEDIMENTATION . . .

Key to Appalachian Production

by Earl H. Linn

THE Appalachian basin is principally a basin of Paleozoic deposition. There are all known Paleozoic formations present: Pennsylvanian, Mississippian, Devonian, Silurian, Ordovician, and Cambrian. The Northern Appalachian basin has produced oil and gas down to and including the Silurian formation. Ninety per cent of this production has been found in stratigraphic traps.

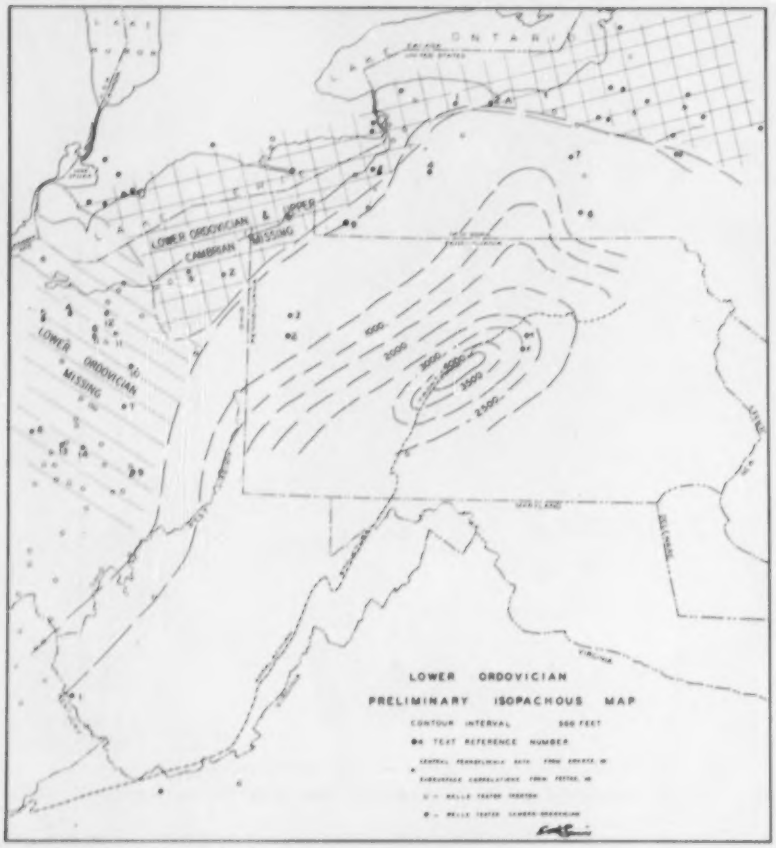
Without having any other geologic knowledge, one would think that the average independent oil operator would continue to search for more stratigraphic traps in the deeper formations. Unfortunately, this is not true. Somewhere along the way, geologists impressed these operators with the idea that the deeper formations would be productive only on large structures.

Probably the main reason for this thinking was that the geologists had the Middle Ordovician (Trenton limestone) in mind as a deeper possible pay. It is true that the Trenton needs large structures to produce. Everywhere that it does produce, it does so from dolomitized limestone which occurs along the axis of a local or regional fold. It is not necessarily true for the Lower Ordovician and Upper Cambrian formations. These formations seem to be over looked. Even today, in some quarters, a deep test still connotates Trenton limestone.

In the late '30s and early '40s several major oil companies entered into a large exploration program in the northern Appalachian basin. They had seismograph, gravity, and magnetometer crews working, all with the hope of uncovering some large undetected structures that would warrant some deep tests. Having found none, they left the area, discouraged and with a bad memory. They, too, had overlooked the past productive history of the basin, i.e., stratigraphic accumulation, with little regard for structure, is the rule, rather than the exception.

Deep strat plays . . . Realizing that the Appalachian basin was a basin of subsidence and emergence throughout the Paleozoic time, and that the older production was governed by stratigraphy rather than by structure, then the logical exploration approach is to search for areas favorable for stratigraphic accumulations in the deeper Cambro Ordovician section. The locations of old shore lines, unconformities, pinchouts, and facies changes are of utmost importance in this search. To find these favorable areas, a study of the paleogeography and depositional history of the Appalachian basin during Cambrian and Ordovician time is necessary.

In this paper, the Middle Ordovician refers to the Trenton and Black River



THE LOWER ORDOVICIAN section thins to the northwest and the 500-ft. contour represents the hinge line of the old basin. Fig. 2.

limestones; the Lower Ordovician refers to the Larke dolomite in Pennsylvania and the Tribes Hill limestone in New York; and the Upper Cambrian refers to the Mines dolomite and Gatesburg sandstones in Pennsylvania and the Little Falls dolomite and Theresea sandstone in New York. Because of the lack of data, all of the accompanying maps are titled preliminary, and are of a regional nature.

The unconformity at the base of the Middle Ordovician offers the best possibilities for deeper stratigraphic-type traps. Fig. 1 is a regional subsurface map, contoured on the base of the Middle Ordovician or the top of the unconformity. As can be seen from the few widely spaced wells, no noticeable reversals have been found to date. There have been too few wells drilled to say that there are not any reversals present. The regional structure contours parallel the present boundaries of the basin.

Lower Ordovician . . . Fig. 2 is a regional isopach of the Lower Ordovician. The Lower Ordovician crops out along the structural front in Central Pennsylvania, and the data used in this part of the map are a modified version of Swartz's work. There is a decrease of some 4,200 ft. of Lower Ordovician section from the mountain front westward to northeastern Ohio, northwestern Pennsylvania, and southwestern New York. This decrease in section is due partly to convergence, but mostly to offlap of the younger beds. In northwestern Pennsylvania and southwestern New York, only the lowest member of the Lower Ordovician is present. The 500-ft.-thickness contour line represents a hinge line of the old basin. Eastward from this line, the section thickens rapidly, while westward and northwestward, the section spreads out along a stable shelf area, until it pinches out. This regional map reveals that the original southeast direction of dip, for the Lower Ordovician and Upper Cambrian, is the same as the later deposited Silurian, Devonian, Mississippian, and Pennsylvanian. If there was any early movement of oil or gas along the unconformity, i.e., at the top of the Lower Ordovician, either during or after deposition, then the great percentage of accumulation would be west of the hinge line, along the apparently stable northwest shelf.

Appalachian Exploration

From this map, you can see that there was a positive area, west, northwest, and north of the basin of deposition. It seems that the area in East Central Ohio was either a depositional barrier, or an erosional high, during or after Lower Ordovician time. This depositional barrier, or erosional high, became more pronounced from Central Ohio northward into northeastern Ohio, northwestern Pennsylvania, and southwestern New York, where the uppermost Cambrian together with the Lower Ordovician either was not deposited or was eroded away. Here, in this area marked Lower Ordovician and Upper Cambrian missing, the Middle Ordovician overlies the basal Upper Cambrian.

Results of Previous Deep Drilling

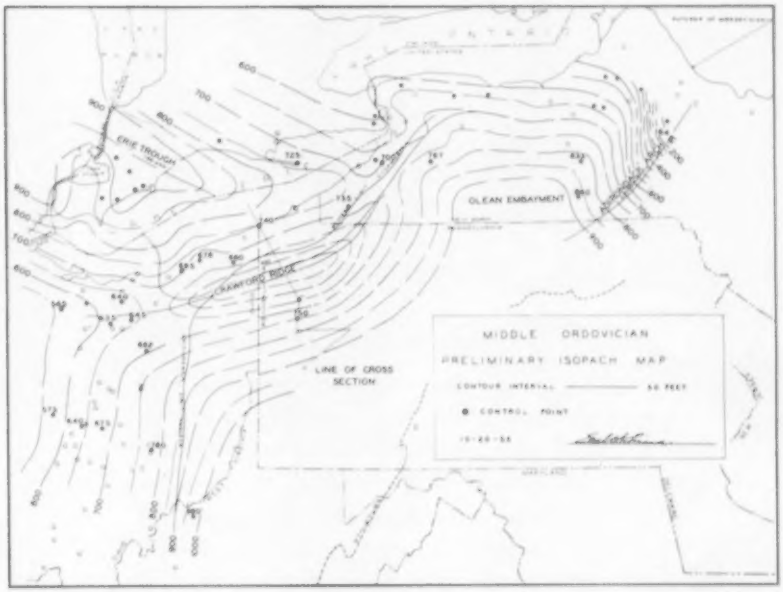
Well No. 2, Manufacturers Light & Heat I Hockenberry, in western Pennsylvania, cut 187 ft. of Lower Ordovician from 9,553 to 9,740 ft. with the top of the formation being at a subsea depth of 8,274 ft. No fluids or gas were encountered. This well drilled 308 ft. of Upper Cambrian dolomite. The top of the Upper Cambrian was reported by Fettke at 9,553 ft., and it logged a good show of gas at 9,746-71 ft. which failed to respond to acid treatment. The top of the basal Upper Cambrian sandstone was reported at 10,048 ft. and the hole was bottomed out in this formation at 10,096 ft. At 10,092 ft. one bailer of salt water per hour was recorded.

Twelve miles north of the Hockenberry well, United Natural Gas 1 Davidson well No. 3, was drilled to a total depth of 8,892 ft. This well drilled approximately 65 ft. of Lower Ordovician dolomite, and was bottomed out in the same, when the well was plugged and abandoned. This well logged salt water from 8,876-80 ft. and from 8,889-92 ft. The hole filled with 200 ft. of salt water.

Ohio Oil Co. 1 Childs, well No. 1,

THE AUTHOR

Earl H. Linn is exploration geologist for the Benedum Interests, Pittsburgh, and a director of Penn-Ohio Gas Co., and Hiawatha Oil & Gas Co. He graduated from University of Pittsburgh in 1949 with a bachelor of science degree in geological engineering. At that time, he joined the Benedum organization and has been with it since then. He has worked in the Mid-Continent area, Oklahoma, Kansas, Texas, Rocky Mountains, Southeastern States, Michigan, Southern Ontario, and the Appalachian basin.

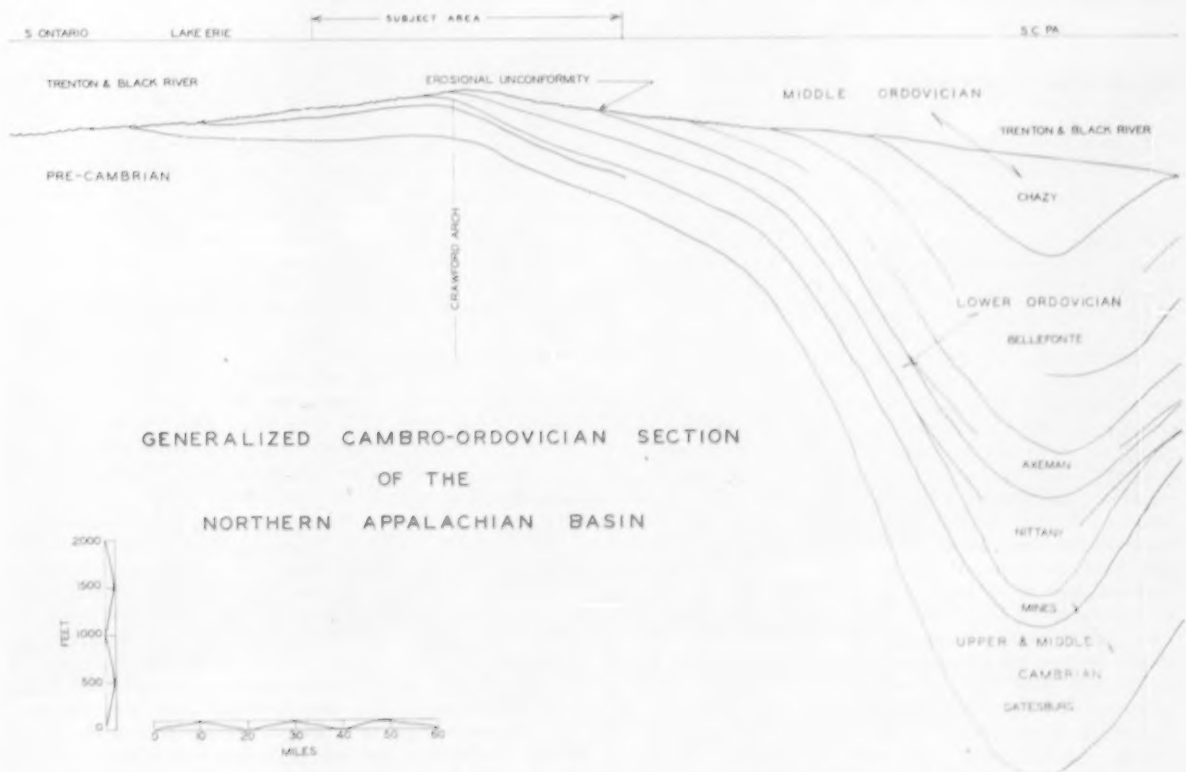


AN ISOPACH MAP of the Middle Ordovician beds reveals several interesting structural elements; the most prominent of these is the Crawford ridge. Fig. 3.

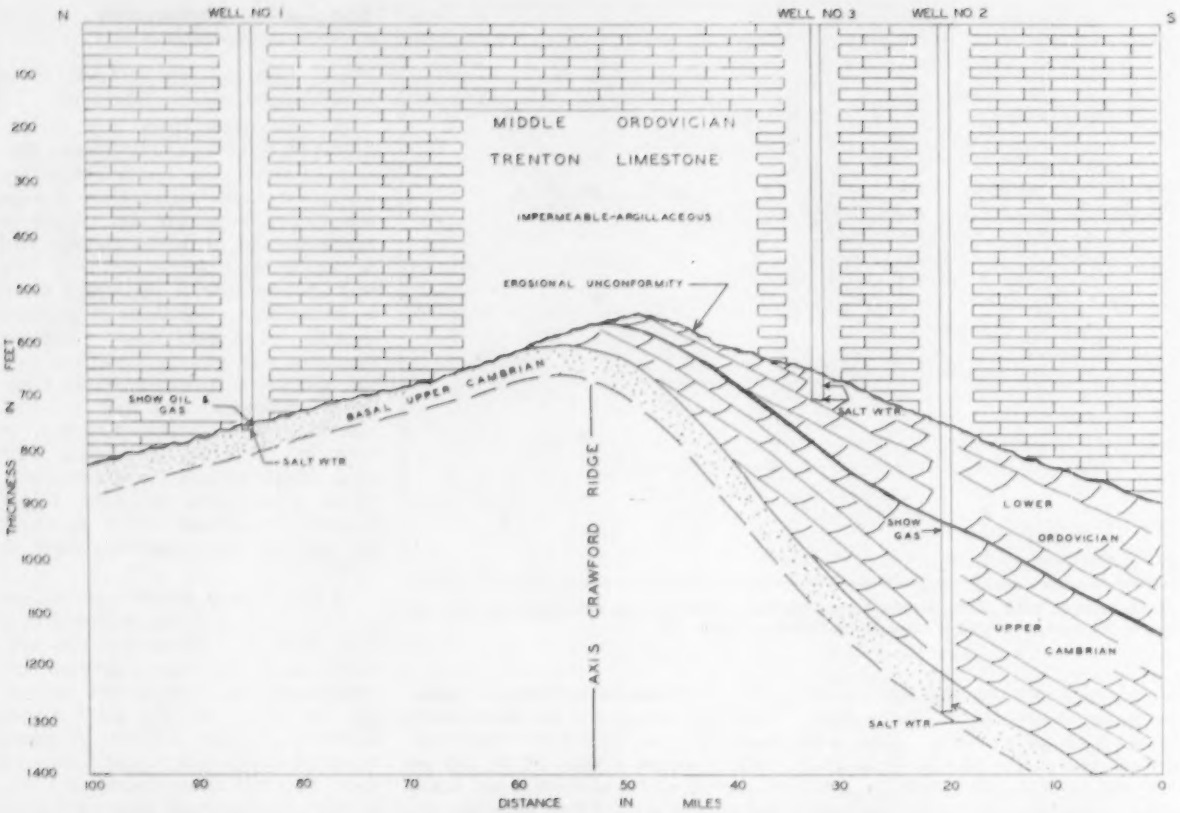
in northwestern Pennsylvania found the Lower Ordovician and Upper Cambrian dolomites missing. This well drilled through the Middle Ordovician into the basal Upper Cambrian sandstone, at a depth of 5,179 ft. This sandstone, as correlated by Fettke, is equivalent to that logged in the Hockenberry well, No. 3, at 10,048 ft. The Childs well, 1, logged a show of oil and gas in the top of the sandstone, and a hole full of salt water 12 ft. from the top. It was bottomed out at 5,191 ft. in basal Upper Cambrian sandstone.

In New York state, well No. 4, drilled 86 ft. of Lower Ordovician formation. Here, the Lower Ordovician was a limestone, rather than a dolomite. The formation was topped at 6,109 ft. and at 6,182 ft. the well logged 25 M.c.f. of gas per day. This well also cut 130 ft. of Upper Cambrian dolomite. No fluids or gas were reported. The basal Upper Cambrian sandstone was 643 ft. thick, and carried salt water, as did the Middle Cambrian sandstone. This well was bottomed out in the Middle Cambrian at 7,144 ft. Well No. 2, in New York state, drilled through the Middle Ordovician section into the basal Upper Cambrian sandstone, which is where the hole was abandoned, at a depth of 4,602 ft.

In the extreme southwestern corner of New York, well No. 9 drilled to a total depth of 7,100 ft. and was bottomed out in the Upper Cambrian dolomitic sandstone. It reported a show of gas, 90 M.c.f. per day from 6,880-6,889 ft. in sandy dolomite of either Lower Ordovician, or Upper Cambrian age. This well also encountered 3 bbl. of salt water per hour from the Upper



THIS REGIONAL CROSS-SECTION extends from South Central Pennsylvania northwestward into southern Ontario. Fig. 4.



DETAILED STRATIGRAPHIC CROSS-SECTION through the Crawford arch shows several possible oil or gas traps. Wells No. 1 and No. 2 logged shows of oil or gas. Fig. 5.

Appalachian Exploration

Cambrian dolomite sandstone, at the total depth of 7,100 ft.

Middle Ordovician

A preliminary isopach map of the Middle Ordovician limestones, that lie directly above the unconformity, is shown in Fig. 3. Superimposed on this map are the approximate western limits of the Cambro-Ordovician dolomites and limestones. On the eastern side of the map, the Middle Ordovician limestones show a regional thinning across an area that Kay has referred to as the Adirondack arch. This thinning also is reflected in the Lower Ordovician isopach map. This author has given the reentrant in southwestern New York the name of Olean embayment because of its proximity to the city of Olean.

In northwestern Pennsylvania the Middle Ordovician limestones seem to be thinning over an area which this author refers to as the Crawford arch because of its proximity to Crawford County, Pennsylvania. The area in southwestern Ontario and Lake Erie is referred to as the Erie trough, because of the increased thickness of the Middle Ordovician limestones in this area.

To clarify this postulated ridge or arch, two cross-sections are shown Figs. 4 and 5. Fig. 4 is a generalized Cambro-Ordovician cross-section across the entire northern Appalachian basin. This section starts in South-Central Pennsylvania and extends, N45°W, into southern Ontario. Its purpose is to show how the Middle Ordovician limestones overlap successively older beds from central Pennsylvania to southern Ontario, where they overlie the Pre-Cambrian. Also it shows the location of the subject area in relation to the rest of the basin.

Fig. 5 is an enlarged cross-section of the subject area, showing the locations of the test wells and the results of the same.

The well farthest south on this cross-section No. 3, logged 750 ft. of Middle Ordovician limestones. The Davidson well, No. 2, 12 miles to the north logged 640 ft. of Middle Ordovician limestone. The Childs well, No. 1, at the common corner of northeastern Ohio and northwestern Pennsylvania logged 742 ft. of Middle Ordovician limestones. Another well, not shown on the cross-section, but which is further evidence of the postulated arch, is the Chester well, located just west of the 600-ft. figure on Fig. 2. This well logged 660 ft. of Middle Ordovician limestone. Also of interest is the Morse well in the extreme southwestern corner of New York State, which logged, according to this author, approximately 735 ft. of Middle Ordovicoan limestone. The New York State survey reported the Middle Ordovician as being 803 ft. thick. If its correlation is true, then the pre-Middle Ordovician features in Fig. 3 would be more pronounced than are shown. (Note: This map, along with the others, is this author's interpretation. With so few data available, each geologist has a wide interpretative range).

These cross-sections, although greatly exaggerated, do show the feasibility of a broad, low relief, pre-Middle Ordovician arch or ridge having been present. If such feature was in existence, then the Lower Ordovician and Upper Cambrian dolomites that were deposited on its south flank, and possibly over it, would have been subjected to a longer period of erosion before Middle Ordovician deposition, and subsequently, would have developed secondary solution porosity. If this is

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Appalachian Exploration

so, it really could explain why the Davidson well found the Lower Ordovician to be porous, while the Hockenberry well, located farther in the basin and off the ridge, found the same formations to be nonporous. Also it would seem that as you moved northwestward toward the old Cambrian positive area, the primary porosity would increase, due to the increase in sand content being derived from the old high. If this high area had at one time received Upper Cambrian sediments, and was later eroded, it also would give rise to a more arenaceous character to the Lower Ordovician and Upper Cambrian when they are found close to their northwestern limit. The reason for this is that the beds exposed to weathering would have been beds of middle Upper Cambrian, which are principally sandstones.

Based on the present information, the middle Ordovician limestones will not thin to less than 550 ft. of thickness across the Crawford arch. This would indicate that the unconformity at the base of the middle Ordovician was not caused by a rejuvenated land mass, but by a subsidence of the basin, with its accompanying offlap, of the Lower Ordovician and Upper Cambrian sediments. Fluctuating shorelines, with continued subsidence, exposed successively younger beds to erosion from west to east before the middle Ordovician was deposited. These conditions undoubtedly gave rise to pinchouts, local and regional unconformities, and shoreline-type deposits, which are some of the necessary prerequisites for stratigraphic-type reservoirs. The showing of oil and gas found in the wells drilled eliminate the question as to whether the formations below the middle Ordovician unconformity are petroliferous.

Lease Status

The lease situation in northwestern Pennsylvania, southwestern New York, and northeastern Ohio is very diversified. Some of the acreage is held by shallow production. The operators of this shallow production are for the most part independents or small companies, incapable of large exploratory progarms. Their production is all stripper oil wells. The utility companies own various-sized spreads throughout the favorable areas. These blocks are not contiguous, nor are they solid. They are mostly protective spreads, i.e., 3,000 acres in one township, 1,200 acres in another, etc. It is reported that several companies and individuals are in the process of leasing large unitized blocks of acreage along this trend.

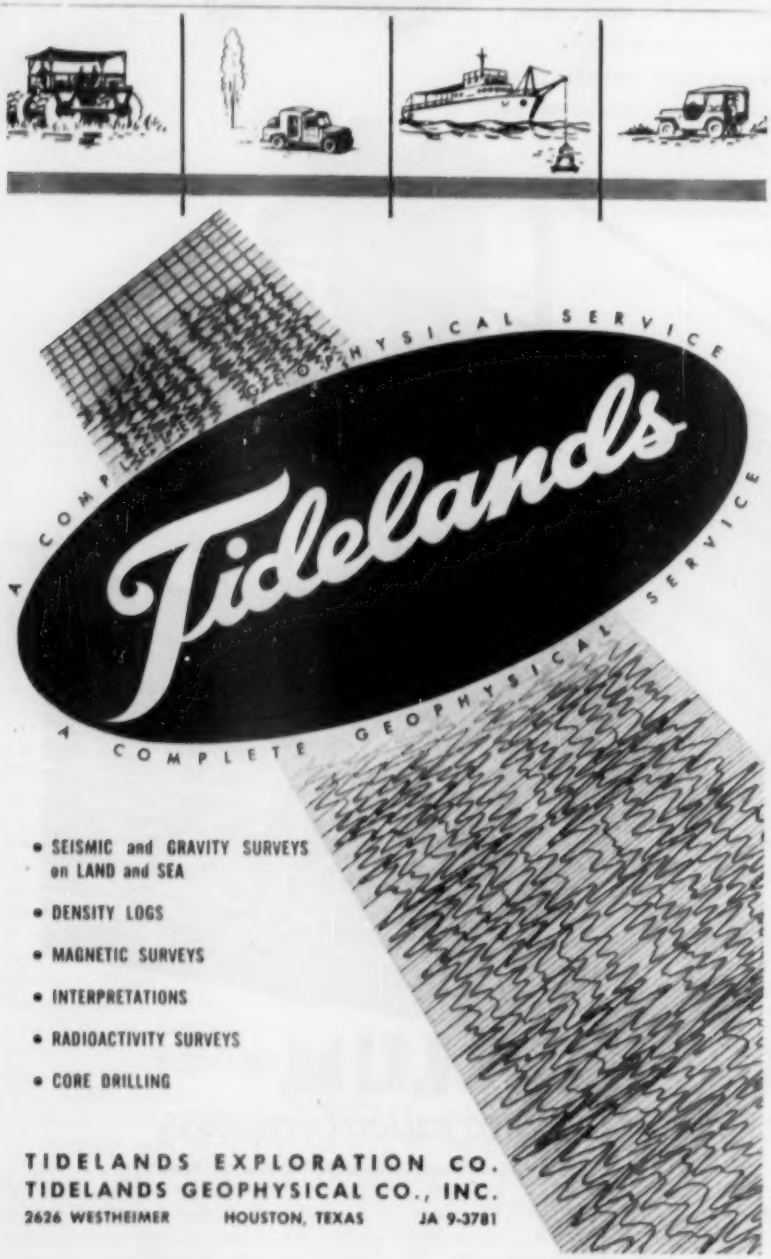
From all indications it looks as if a lease play may be developing. There are still, however, many acres unleased, including the deeper rights under much of the shallow production.

Economics

The drilling depths should range between 7,000 and 9,000 ft. and either cable tools or rotary tools could be used. Both types of drilling are being used in the search for new Oriskany gas production in north-central Pennsylvania and southwestern New York. Air-rotary drilling has been very successful in the Appalachian basin, and this has reduced the cost of deep drilling considerably. This type of drilling should be very adaptable to Cambro-Ordovician prospecting, inasmuch as there would be from 2,000 to 2,500 ft. of Upper Ordovician shales to drill.

Any Cambro-Ordovician test also will drill several potential producing horizons, before reaching the main objectives. The Lower Devonian, Oriskany sand, the Silurian dolomites, and the Silurian sandstones all lie above the object depth. All of these formations are commercially productive, at one place or another, in the northern Appalachian basin.

The Appalachian basin is in the heart of the large eastern markets. The established field price for dry gas at the well-head varies from $0.25 per



Exploration drilling is made more economical with Mayhew rotary air drilling rigs (above), equipped with special Republic Rubber hose.

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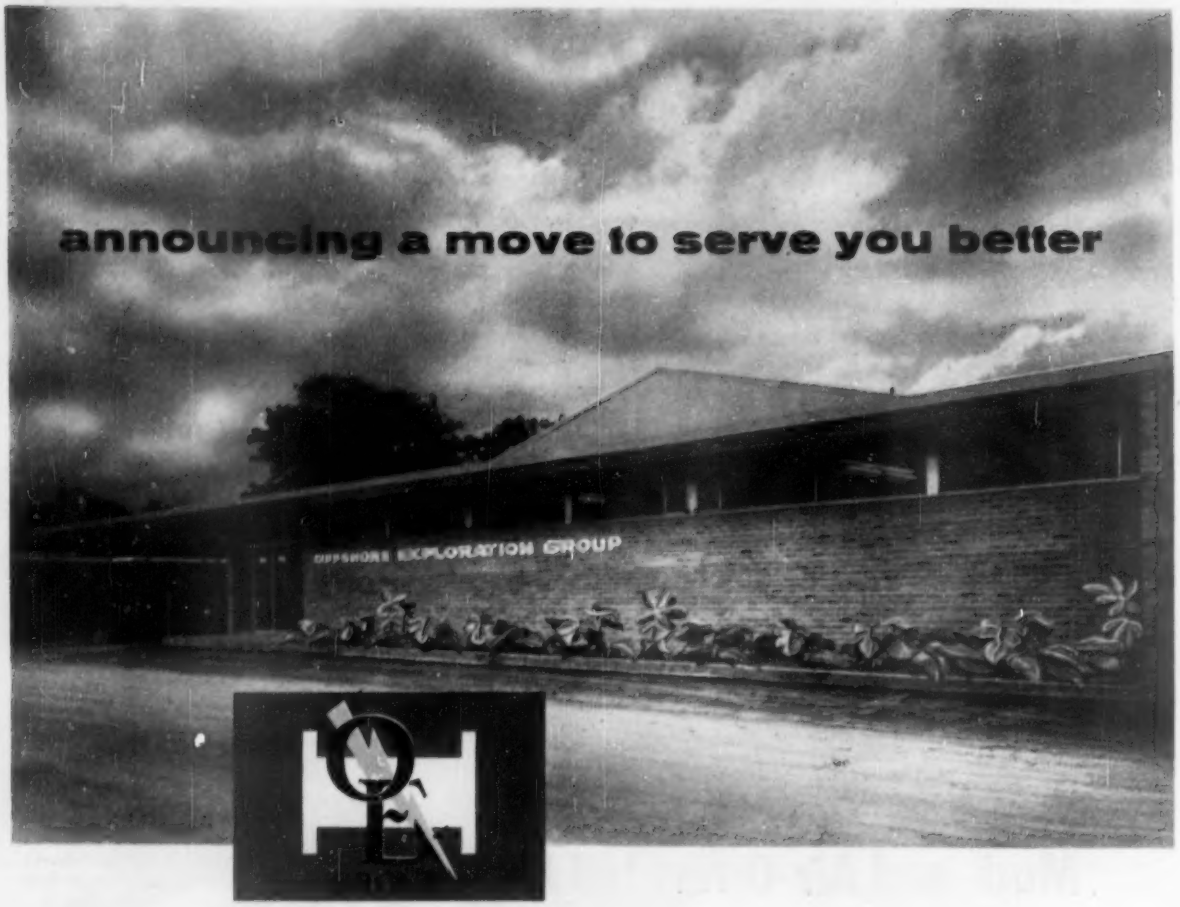

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Appalachian Exploration

M.c.f. in the central part of the basin, to $0.35 per M.c.f. in the northern part of the basin. There is no state proration, and only in a few instances is there pipeline proration. The price for oil ranges from $3.75 per barrel in the Middle District, to $4.00 per barrel in the Bradford District. There also is no proration on oil production. These high prices for gas and oil, together with no production restrictions, offer the investor a quicker return for his investments, if successful, than most other producing basins. It is not unusual for a good Oriskany gas well that costs $75,000 to $80,000 complete, to return the capital investment in 60 days.

Conclusion

The geologic evidence points to possible new oil and gas production in the deeper formations of the Appalachian basin. Only three wells have tested the Lower Ordovician on the northwestern stable shelf, one of these has found gas shows, one has found salt water, and the well deepest in the basin has found it to be nonporous. Only three wells have tested the Upper Cambrian dolomites. The one in Pennsylvania had a good show of gas, and the one in western New York had no shows, while the other in southwestern New York had good shows of gas. Two wells in Pennsylvania have tested the basal Upper Cambrian sandstone, one had a show of oil and gas, the other had salt water.

Sedimentation is the key to Appalachian production. This author has attempted to show a regional area that should have received favorable sediments, and undergone favorable geologic history, to give rise to reservoirs and traps. The Cambro-Ordovician dolomites of the Appalachian are equivalent to the Cambro-Ordovician limestone and dolomites in the Mid-Continent and west Texas. It remains to be seen whether they will be as productive in the Appalachian basin as they are in the other Paleozoic basins.

Acknowledgments

The author thanks C. R. Fettke and F. M. Swartz for the use of their data. Without their work, this paper could not have been written; Fettke for his well-sample studies and subsurface correlations, and Swartz for his field studies and surface correlations.

Also acknowledgment is extended to Hiawatha Oil & Gas Co. for permission to publish this paper.

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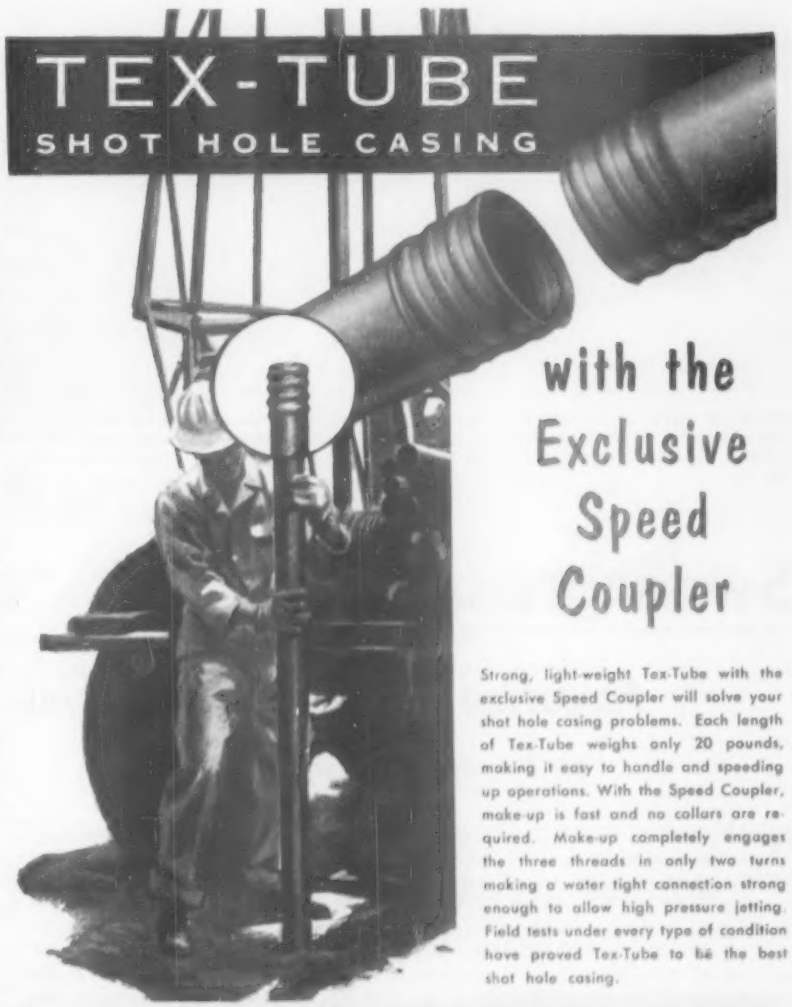
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MOST OF MONTANA'S OIL has come from the fields of the Sweetgrass arch in the northwestern part of the state. Tectonic map of the region shows major producing areas, recent Madison discoveries, and the important Union 1 Morning Gun wildcat, completed in 1955. Fig. 1.

Sweetgrass Arch . . .

Forgotten Corner of the Rockies

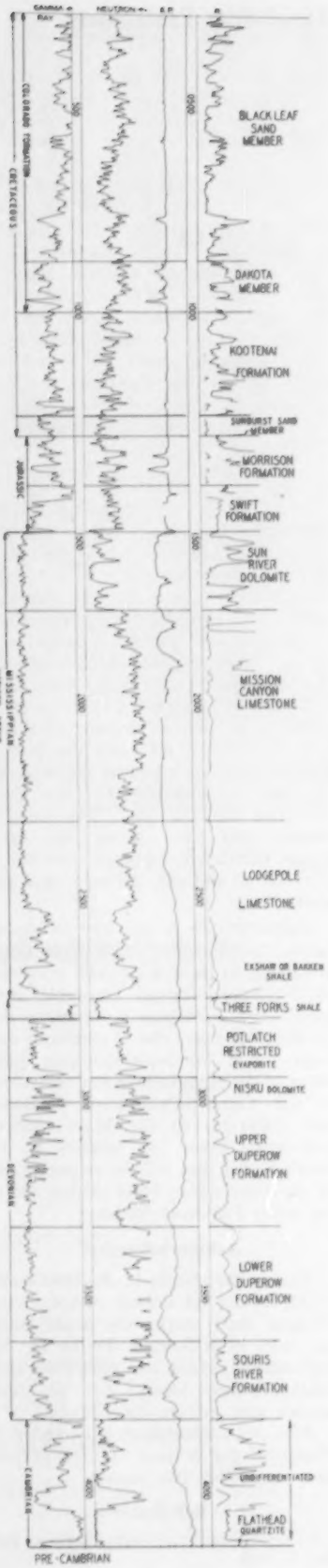
by Edward A. Gribi, Jr.

NEARLY three-quaters of all the oil produced in Montana to date (over 200 million barrels) has come from the 3 major fields and 11 smaller pools of the Sweetgrass arch of the northwestern part of the state. And probably 99 per cent of this oil has been produced from depths of less than 3,500 ft.

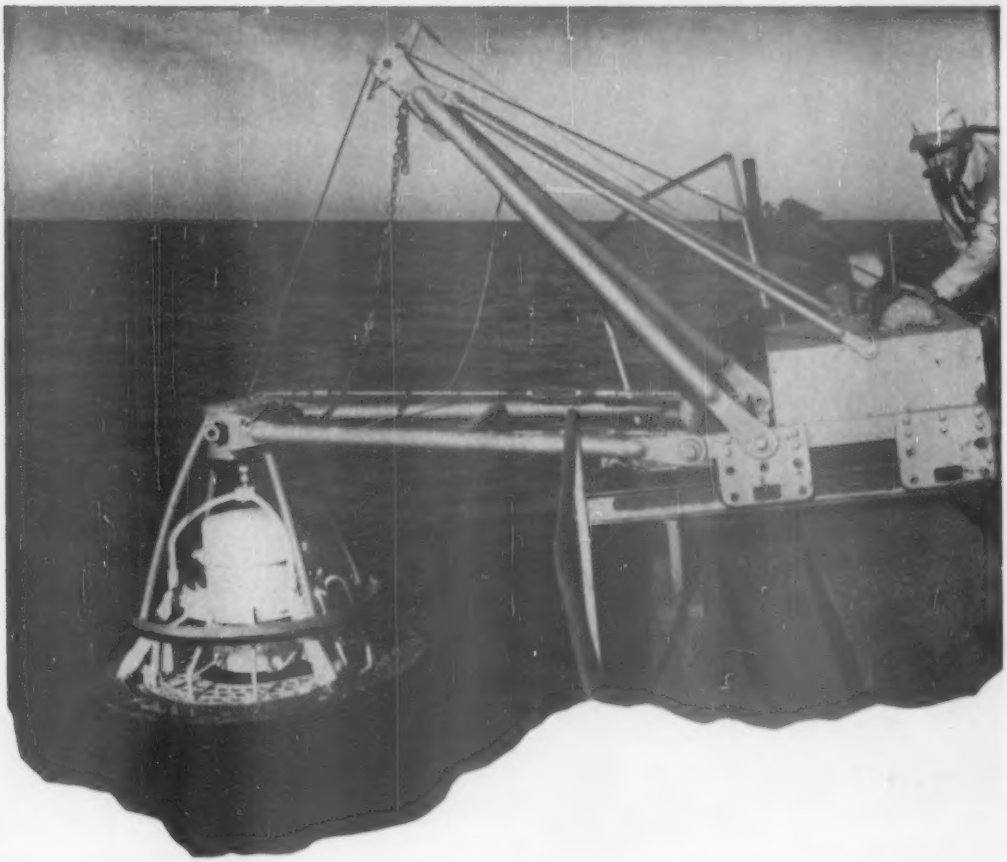
Yet up until very recently the Sweetgrass arch has been one of those forgotten corners of the American oil picture remote geographically and remote in the minds of those who guide oil exploration. It is becoming less remote geographically as transportation means are improved and it is becoming less remote in the minds of oil explorers as its importance as a relatively shallow petroliferous province becomes known.

An oil province . . . Certainly the criteria for the existence of an oil province are present: from 5,000 to 7,000 ft. of sediments of Mesozoic and Paleozoic age and of shelf facies cover this 20,000 sq. miles immediately east of the Cordilleran geosyncline. Evidences of oil and gas are of the most substantial type—producing oil and gas fields.

At least one regional unconformity



TYPE ELECTRIC LOG of region is General Petroleum 88-30P Holt, 30-25n-1w, Teton County. Elevation 3,594 ft. kelly bushing, total depth 4,151 ft. Spud, January 1, 1950. Abandoned, October 22, 1950. Fig. 2.



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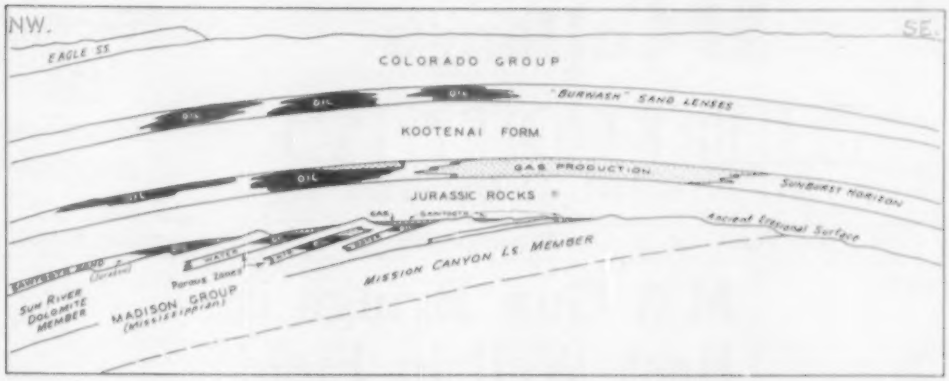

KEVIN-SUNBURST FIELD has produced 60 million barrels of oil to date, mostly from the complex traps at the top of the Madison. Fig. 3.

Sweetgrass Arch

and several lesser ones divide the sedimentary section into several layers of geology each with its own set of structural and straigraphic conditions to control accumulation. Wedge belts of permeability exist on a large scale in all parts of the section and are known to be the broad control for most of the oil found to date. Let's take a closer look at this oil province.

Structural picture . . . The Sweetgrass arch is a broad northerly plunging anticline that has its roots in the Belt Mountains south of Great Falls (see Fig. 1). It finally disappears as a trend in southern Alberta. Its eastern boundary depends on the viewpoint, for it continues dipping gradually to the east toward the Williston basin with few interruptions. On the west the complexly folded and faulted structures of the Disturbed Belt in the Front Range disrupt the pattern. In like manner sediments disappear almost completely to the west within a few miles in the Disturbed Belt as pre-Cambrian rocks are thrust to the surface. Dips over the arch proper average less than a degree. Local anticlinal closures are common but faulting is quite widely spaced.

Stratigraphy

. . . Cretaceous marine sands and shales cover the surface and extend to an average depth of 1,000 ft. or so over the crest of the arch. Several sands in this section are of importance as gas producers but oil production has to date been negligible. The nonmarine Kootenai formation of Lower Cretaceous age is from 300 to 500 ft. thick and contains several oil and gas-producing sands, notably the Moulton and Sunburst near its base.

. . . Jurassic rocks include marine sands, shales, and limestone and range from 100-400 ft. thick. Important oil sands in this group include the Cutbank, Swift, and Sawtooth.

. . . Mississippian. The regional unconformity between the Jurassic and the Mississippian provides traps in the onlapping Jurassic strata and in the eroded edge wedge belts of permeability in the Madison group.

This situation reaches its climax in Kevin-Sunburst field where the two types of traps mingle in a maze of stratigraphic traps which to this day defy engineering analysis, let alone geologic prediction of future producing areas. The Madison limestone averages around 1,000 ft. thick and occurs at an average depth of 2,000 ft. over the north part of the arch. The Sun River dolomite member occurs at the top ranging from several hundred feet thick on the west to nothing along the east side where it wedges out. It has provided most, if not all of the Madison production to date, and few wells have tested the Madison below this horizon. Thus most of the wells in the region have tested no deeper than 2,500 ft.

. . . Devonian rocks average around 1,000 to 1,500 ft. thick and consist of limestone, dolomite, anhydrite, and shale. The majority of the dozen or so wells that have penetrated this section have had oil and gas shows in zones of relatively low permeability. Cambrian sand, shale, and limestone average less than a thousand feet thick and rest on pre-Cambrian basement complex. A "deep test" on the Sweetgrass arch may thus be as shallow as 4,500 ft. No shows have been reported in the Cambrian.

Sweetgrass Oil History

The Sweetgrass arch oil industry started in 1922 with the discovery and subsequent boom development of Kevin-Sunburst field. This field has produced 60 million barrels of oil to date, mostly from the complex traps at the top of the Madison (see Fig. 3). Oil and gas are also produced in profitable quantities from shallower Cretaceous sands. It should be pointed out that despite the complete lack of ability of geology to predict in this field, the ratio over the years has been about four producers to every dry hole within the general limiits of the field. Yet less than half of the acreage within these limits has been tested by drilling. Add to this the potential from the introduction of modern techniques and the possibilities of deeper drilling, and Kevin-Sunburst takes on more impressive character even though the present production is about 2 bbl. per day per well from 1,400 wells.

Cut Bank field was discovered in 1931 and 80 million barrels of oil had been produced from it to the end of 1955. Its 1,100 wells now produce about 7,500 bbl. per day. This field is a large-scale lens of Jurassic sand and is the best field in the Sweetgrass arch. It indicates the importance of stratigraphic type accumulations in this area.

Pondera field was discovered in 1928 and has produced 12 million barrels to date from porous zones in the Sun River Dolomite portion of the Madison. Other small oil and gas pools, notably **Whitlash** field, were discovered in Cretaceous and Jurassic sands in the Sweetgrass Hills area northeast of Kevin-Sunburst in the early thirties.

Border and Darling pools northeast of Cutbank field were discovered in this same period but their important development came in 1954 with the exploitation of the prolific Moulton sand reservoir. **Reagan,** a Madison

THE AUTHOR

Edward A. Gribi, Jr., is a consulting geologist of Great Falls, Mont. A California native, he received his B.S. in geology from Stanford University in 1948. He then served Phillips Petroleum Co. as reconnaissance geologist, Sinclair Petroleum Co. as a junior geologist in Ethiopia, and General Petroleum Co. as assistant geologist, resigning in 1953 to go into business for himself. He is a producer, with production in Bannatine field, Teton County, Montana.

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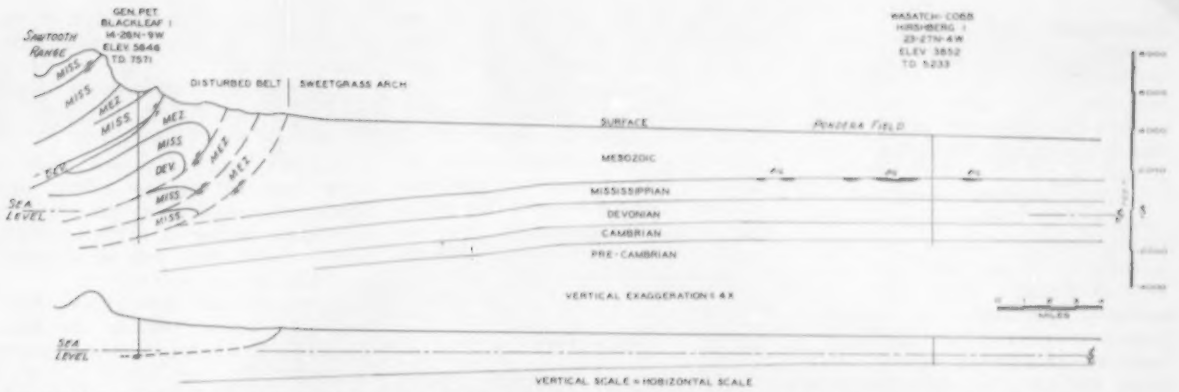
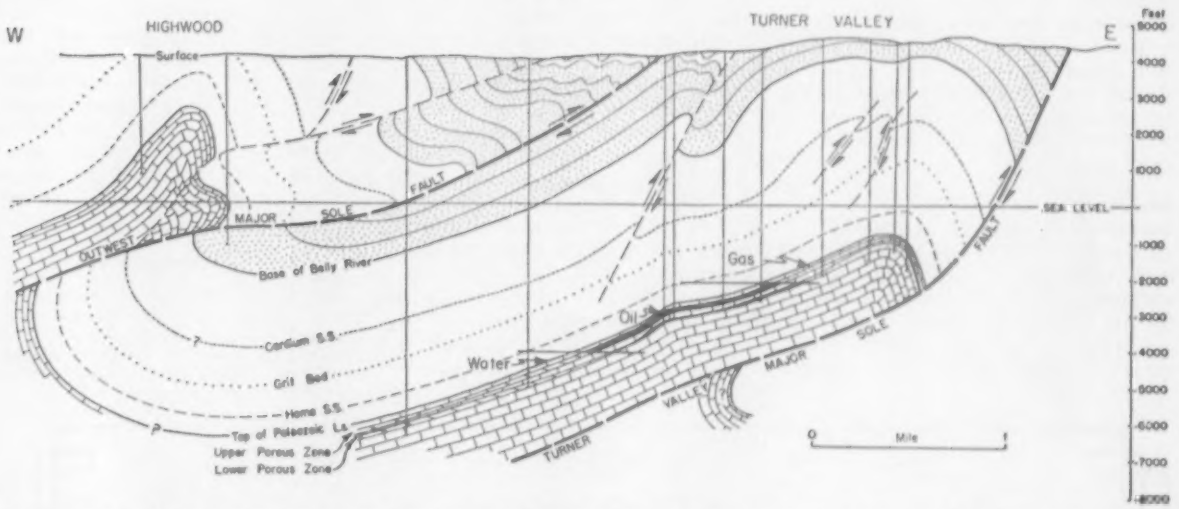


WEST-EAST CROSS-SECTION (see Fig. 1) extends from the Rocky Mountain pre-Cambrian front through the Disturbed Belt to the Pondera field area. Fig. 4.



A SECTION THROUGH TURNER VALLEY FIELD in Alberta illustrates what may be expected from similar structural circumstances in Montana's Disturbed Belt. Fig. 4a.

Sweetgrass Arch

lime pool northwest of Cut Bank, was discovered in 1941 and the 30-odd wells have produced a million and a half barrels to date.

Development Techniques

Techniques used in development of these fields and in wildcat exploration have lagged considerably behind the industry elsewhere up until very recently. Even at present at least three-quarters of the 40 or so active rigs in the region are small cable-tool outfits of 3,000-ft. or less capacity. Coring, electric logging, reservoir data, even the systematic saving of ditch samples have been recent innovations and still are rarely used by the many small independent operators.

Shooting and acidizing have been used since their introduction elsewhere and fracturing and other recent production improvement techniques are being tried by some operators. The use of these techniques has been limited, however, and the result is that a majority of wildcats that have been drilled in this country can not be considered as having condemned the strata they tested. The lack of basic geologic and engineering data on wildcats and field wells means that in many cases information is inadequate for the formulation of prospects and for the evaluation of producing properties.

Certainly one of the bright spots in the picture has been the relatively good market for crude. The four active refineries in the region have a crude capacity of 16,000 bbl. per day and about 14,000 bbl. per day are produced by the arch fields. This is mostly marketed in northwestern Montana. Establishment of substantial additional production, however, would undoubtedly require development of new markets elsewhere.

1955 Was Tops

The year 1955 was one of the most active in the history of the Sweetgrass arch. Perhaps the most significant from the long-range viewpoint was the commencement of serious exploration in the Disturbed Belt area by geophysics and drilling by Union, Gulf, Continental, Shell, and other majors. The Union 1 Morning Gun well was abandoned but not without significant occurrences of oil and gas which could not be produced, perhaps only because of mechanical difficulties. The oil and gas occurrences incidentally came from the relatively undisturbed Mississippian rocks beneath the basal overthrust of the Disturbed Belt (the downdip continuation of the west flank of the arch).

. . . Disturbed Belt. The Disturbed Belt deserves special mention since it is a continuation of the structural province that has provided some of the best Canadian production. Turner Valley, Pincher Creek, and now Savannah Creek all produce from Mississippian rocks involved in the complex mass of rocks that overrides the flat-lying rocks of the plains. Similar Mississippian rocks, in part, continue into Montana in similar structural circumstances and

Sweetgrass Arch

will be the main target of future exploration. Fig. 4 shows a cross-section into the Disturbed Belt with a section through Turner Valley field for comparison.

. . . **New Madison** production was established in several areas in 1955, notably between Cutbank and Kevin-Sunburst fields, and west and northwest of Pondera field. One area, **northwest Pendroy,** has established production from both Madison and Sunburst. **Bannatyne field,** abandoned for 20 years, was revived in 1955 with the recompletion of two old wells as small Swift producers. Additional gas production was established in the **Sweetgrass Hills** area and a possible Sunburst sand oil well is still testing. Sawtooth sand gas production was established in Hill County and one noncommercial oil show was tested in the same sand several miles away.

Reserves gained . . . The addition to the area's reserves by wildcatting is an unknown factor depending on future development. However, solid additions to reserves were chalked up by the many development and step-out wells. These developments were of course almost routine but certain aspects were not.

Cut Bank field in particular saw the widespread use of fracturing, bottom-hole heaters, a pilot water-flood project, with excellent results with all these techniques. These techniques, particularly fracturing, were tried in other fields with scattered success, but again the lack of basic data combined with the restricted usage to date means that these techniques really have not been tried under controlled conditions in areas where they might do some good.

What's Ahead?

I believe 1956 will at least see the following developments in this area:

1. The Disturbed Belt will probably undergo a drilling campaign of at least a half dozen wells along the 150-mile trend. There will not only be wells drilled in the foothills where there may be subthrust prospects, but there will be tests drilled for complex zone prospects of the Turner Valley and Pincher Creek type.

2. A rash of shallow holes (3,000 ft. or less) will test Mesozoic and the west flank of the arch in Teton, Pondera, and southern Toole and Glacier counties.

3. Much wider use of modern completion and production practices will rejuvenate some older producing areas. At the least, portions of Kevin-Sunburst field, and Bannatyne field will be the objects of investigation of the possibilities of these techniques this year.

I believe that the following events may occur in 1956 or most certainly in the next several years:

1. Light rotary rigs will displace cable tools for shallow wildcat and development drilling and there will be a resultant saving in over-all drilling costs. Cable tools will be relegated in tailing in and workover.

2. Shallow-hole drilling and high-resolution seismic will be the most successful exploration tools over much of the arch.

3. Increased availability of electric logs and other basic geologic data will speed exploration for stratigraphic traps in the Mesozoic sediments.

4. Deeper Madison zones and Devonian porosity will become increasingly important as exploration targets.

5. The wider use of better completion practices and new production techniques, including secondary recovery and perhaps in-situ combustion may make producing areas out of many old dry holes.

Reference

"Guidebook, Sixth Annual Field Conference, Sweetgrass Arch—Disturbed Belt, Montana," Billings Geological Society, 1955. This is an expanded version of original article that appeared in The Rocky Mountain Oil Reporter under same title.

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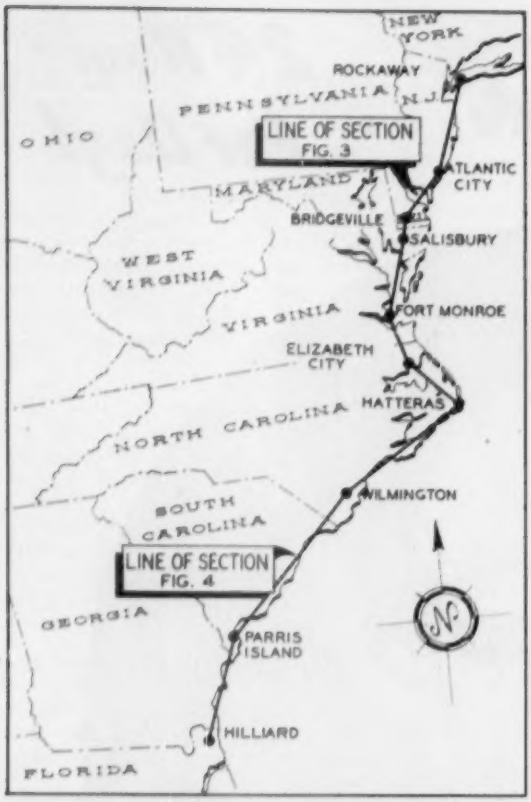
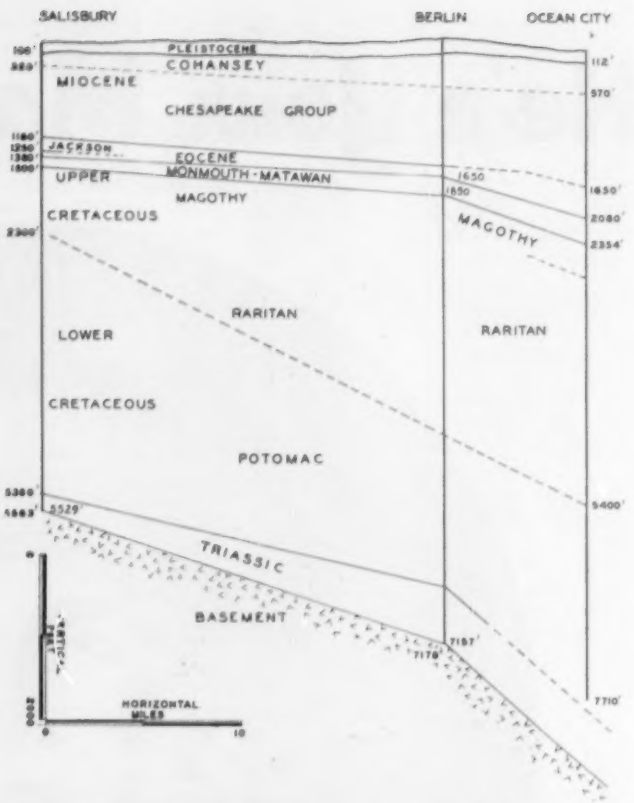


ALONG THE ATLANTIC Coastal Plain, there appear to be several areas where oil might be expected. Sedimentary sections up to 10,000 ft. thick have been penetrated. Fig. 1.



THE SALISBURY EMBAYMENT contains a fairly thick Cretaceous section and the Triassic sediments also thicken seaward. The Raritan is a marine section east of Salisbury. Fig. 2.

Don't Write Off the Atlantic Coastal Plain

. . . Here are suggestions as to where further drilling might be desirable

by Horace G. Richards

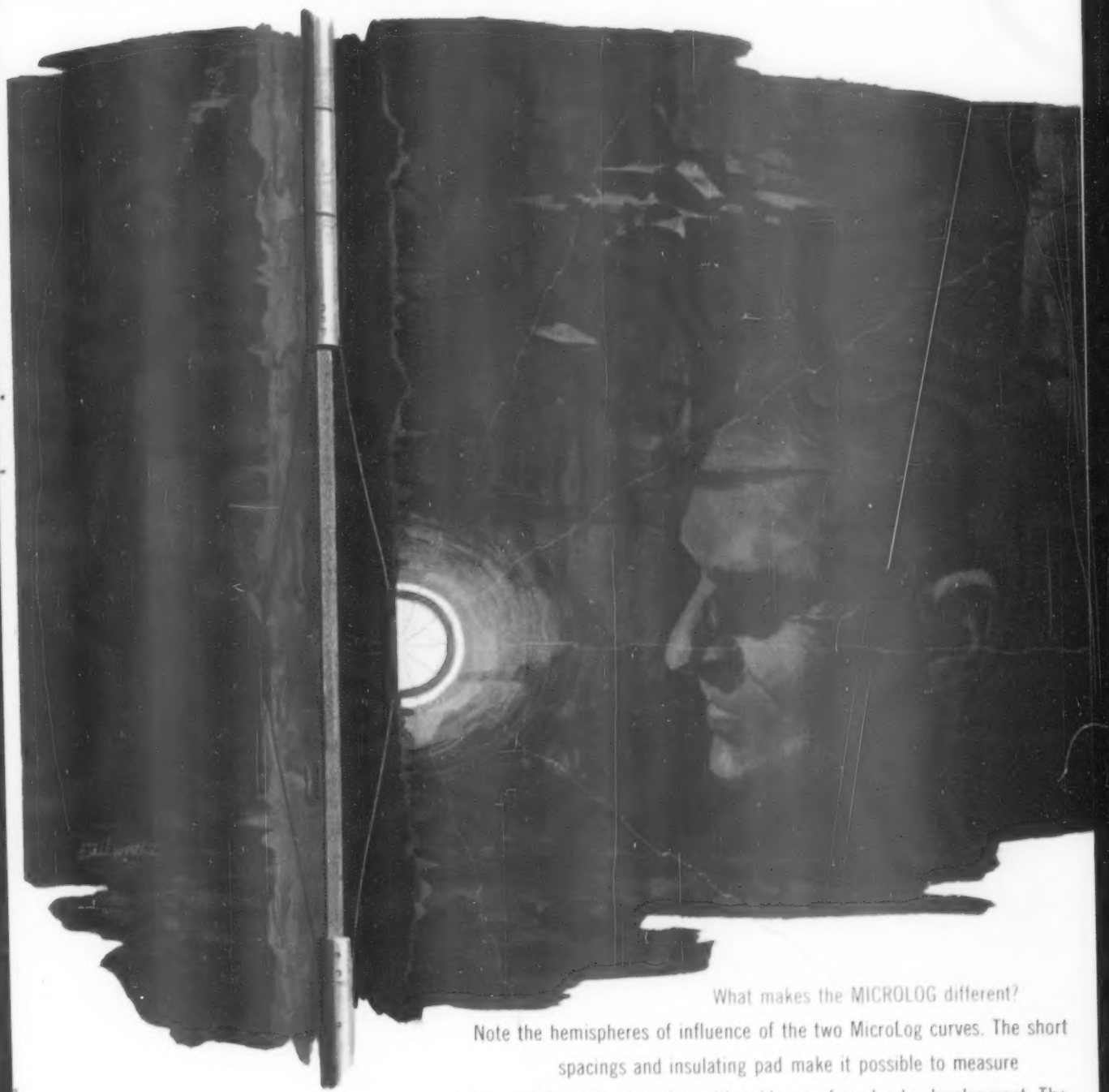
INTEREST in the Atlantic Coastal Plain as a possible source of oil has fluctuated with such factors as wartime need, the abundance of reserves, and the discovery of oil in nearby regions. Need for wartime oil probably inspired the discovery of Sunniland field in Florida (1943) and Gilbertown field in Alabama (1944) and encouraged exploration and drilling as far north as New Jersey.

During postwar years, interest has somewhat lagged, largely because of the failure of three expensive wells of Esso Standard Oil Co. in Maryland and North Carolina and because of the emphasis of the major companies on more promising areas, mostly abroad. However, it cannot yet be said that the area should be written off, and at least several of the major companies are enough interested in the area to jointly support a limited program of geological investigation and compilation undertaken by the Academy of Natural Sciences of Philadelphia.

This article will briefly review some of the features of the stratigraphy and structure of the Atlantic Coastal Plain between Long Island and Florida, and will call attention to recent studies and oil explorations in the region. Emphasis will be placed from Georgia northward, partly because that is the portion of the Coastal Plain stressed in the academy's project, and partly because Florida has now joined the list of oil-producing states and no longer comes under the same category as the Atlantic states to the north.

Long Island . . . It would be too much to hope for the discovery of an oil field on Long Island, practically in New York City's backyard. It is true that Coastal Plain sediments underlie the island, but they are much too thin for any accumulation of oil. Much of the island is made up of Pleistocene glacial deposits which are underlaid by Cretaceous sands and clays correlated with the Magothy and Raritan formations of New Jersey. These Cretaceous deposits reach a thickness of 1,500 ft. or more, but are predominantly nonmarine, adding another unfavorable aspect to the oil possibilities of the island.

New Jersey . . . The Coastal Plain sediments of New Jersey vary in age from Cretaceous to Pleistocene and generally



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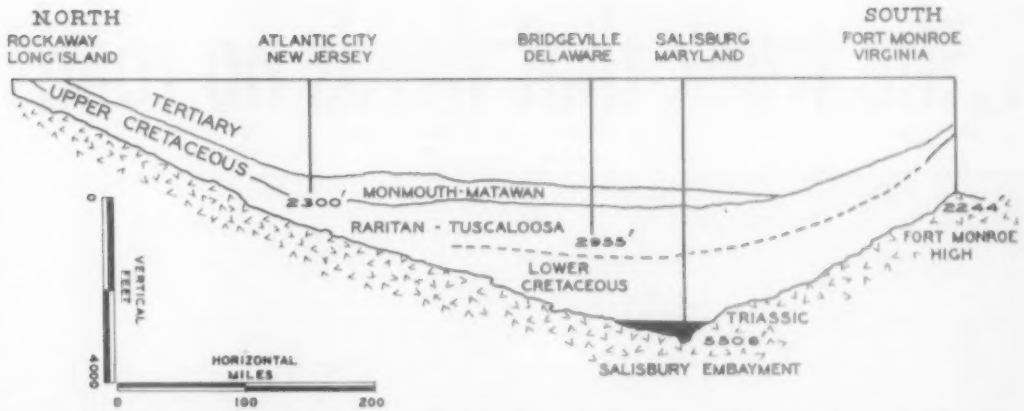


THE SALISBURY EMBAYMENT is evident on the regional cross section that extends from Rockaway, Long Island to Fort Monroe, Va.

dip to the southeast at an average rate of 30 ft. per mile. In most cases the strata thicken downdip, while certain formations, for example those of the Potomac group of early Cretaceous age and the Jackson of late Eocene age, are present only in the subsurface.

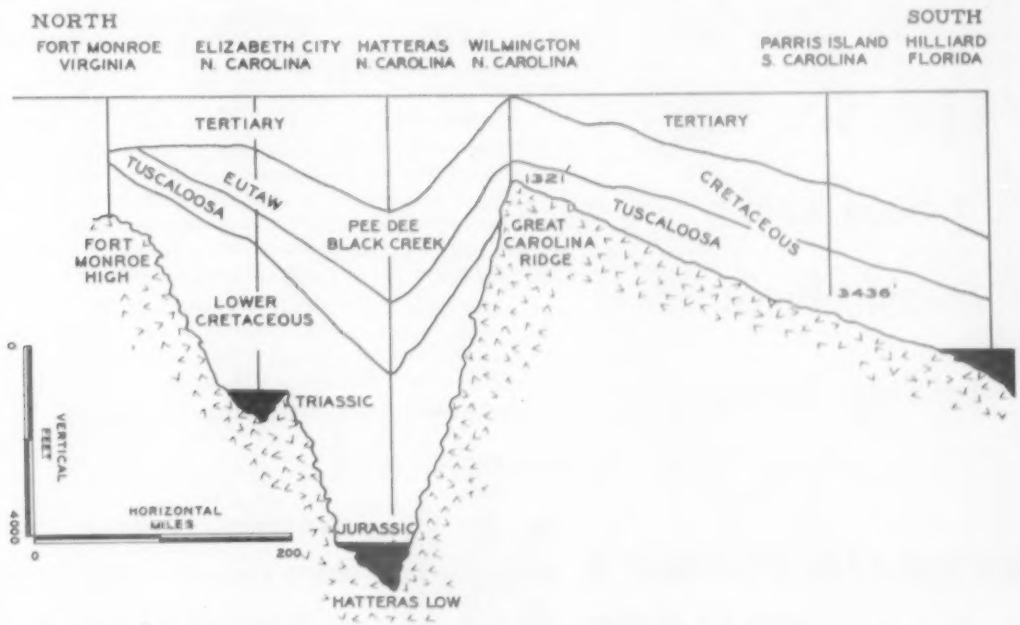
The Tertiary sediments are relatively thin and are generally too near the surface to give much hope for accumulation of oil. On the other hand, the Cretaceous formations with their considerable thickening downdip deserve at least a brief discussion as possible sources of oil or gas. In summary, the New Jersey Cretaceous consists of the basal Raritan formation of alternating layers of sand and clay totaling 150 to 300 ft. thick in outcrop, overlaid by the lignitic sands of the Magothy formation, overlaid in turn by some nine formations, generally alternating sands and clays comprising the Matawan and Monmouth groups. In outcrop, the Raritan and Magothy are predominantly nonmarine, while the overlying Cretaceous sands and clays are marine and are thought to represent slight advances and retreats of the sea.

No significant oil tests have been drilled in New Jersey. Some 10 wells have been drilled, but in practically all cases they were very shallow and did not give an accurate or complete picture of the subsurface geology of New Jersey. The deepest well was one drilled in 1920 at Jackson Mills, Ocean County. this well was 5,022 ft. deep, it encountered basement rock at 1,336 ft., but kept on drilling for more than 3,500 ft. into schist or granite. What a boon to geologists it would have been if this well had been drilled in the southern part of the state where the

Atlantic Coastal Plain

THE AUTHOR

Horace G. Richards is associate curator of geology and paleontology at the Academy of Natural Sciences of Philadelphia. He received his A.B., M.S., and Ph.D. degrees from University of Pennsylvania. While most of his research has been concerned with the Atlantic Coastal Plain, he has also done field work in various parts of the world, including the Caribbean, Arctic Canada, Africa, and various countries of Europe. In 1946, Richards won the President's Award of the American Association of Petroleum Geologists for his paper entitled "Subsurface Stratigraphy of the Atlantic Coastal Plain Between New Jersey and Georgia."



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sedimentary section is much thicker! Other oil tests have been drilled at Prospertown, Ocean County, and near Millville and Newport, Cumberland County.

Recently some valuable information was obtained from a series of test borings and seismic surveys in Burlington and Ocean counties. Some 17 test borings were drilled by Transcontinental Gas Pipe Line Corp. in the hope of finding a structure in the subsurface Cretaceous or other formation that might be suitable for the storage of natural gas. While the project was abandoned as unsuccessful, some valuable information was obtained and will shortly be released by the New Jersey Geological Survey.

One of the significant things shown by these borings is that the Raritan formation becomes more marine downdip and contains a fauna closely related to that of the Woodbine formation of Texas. While much of this downdip Raritan is sand and clay, a few cores showed the presence of a massive limestone. Since the Raritan formation is marine downdip, this section added to the rest of the marine Upper Cretaceous would account for a thickness of some 1,500 ft. of marine sediment which might possibly contain some oil.

No tests have been drilled in the deep subsurface of extreme southern New Jersey, that is, in Atlantic and Cape May counties. The deepest well is an old water well at Atlantic City which stopped near the Matawan-Monmouth contact considerably above the Raritan, at 2,300 ft. On the other hand, geophysical work of Woollard and others suggests that the basement rock dips southeastward at the rate of 65 ft. per mile, increasing toward the coast. Seismic studies made at Avalon, Cape May County, suggest that the basement is below 5,000 ft., so, in the writer's opinion, the most favorable place, or shall we say the least unfavorable place, to drill an oil test in New Jersey would be in southern Cape May County.

While it may be looking far ahead into the future, offshore drilling must not be discounted. If the section continues to thicken to the southeast, becoming more and more marine, it may be desirable to look for oil under the Continental Shelf off southern New Jersey. For example some of the shoals such as McCrie Shoal and Five Fathom Bank, 5 and 11 miles respectively off Cape May, where the water is only about 20 ft. deep, might some day be the location of offshore drilling.

Before leaving New Jersey, a few words should be said regarding the possibility of drilling in the Triassic. The Newark basin occurs northwest of the Coastal Plain and has been regarded as a possible, although not probable, source of oil. Wells have been drilled at Belle Mead and Millstone in Somerset County with no success. It is also known that the Triassic sediments extend under the Coastal Plain in a few places, for example in Middlesex County. It is possible that some future drilling will reveal an extension of the Newark basin, or an entirely new basin, under the Coastal Plain. It is also conceivable that this hypothetical basin may become marine farther east where it connected with the open ocean, and thus may be a potential source of oil.

Delaware . . . The Coastal Plain of Delaware is very flat and few exposures other than Pleistocene can be seen on the surface. The main exceptions are the banks of the Chesapeake and Delaware Canal where various Cretaceous formations can be seen and a few exposures of Eocene glauconite near Middletown and Odessa.

The subsurface geology of Delaware is essentially similar to that of New Jersey except that the nonmarine Lower Cretaceous is represented at shallow depths in northern Delaware and probably below 3,000 ft. in the southern part of the state.

Several oil tests were drilled near Bridgeville, Sussex County, in 1935. While the first well was reported to have shown a few traces of oil, further drilling by Sun Oil Co. failed to confirm the presence of any oil or gas. The well is reported to have stopped at a depth of about 3,000 ft. near the Upper-Lower Cretaceous boundary; it was notable for a section of Eocene thicker than expected (950 ft.) and for the presence of marine fossils in the Raritan formation.

No recent oil activity has been reported from Delaware. In the fall of 1954, the writer received a report of a producing oil well at Gumboro in the extreme southern part of the state. Upon rushing down there, he found that it was a dug well about 15 ft. deep. The alleged "oil" had been discovered some 10 years before and was identified mainly because the cattle would not drink the water, and because of the proximity to Parsonburg, Md., where some gas had been discovered (see below). A careful analysis (in 1954) showed no petroleum.

Maryland . . . There is a conspicuous low in the basement which extends westward from Ocean City through Berlin and Salisbury to the vicinity of Washington. This has been termed the Salisbury embayment (Fig. 2). Most formations thicken in this basin, but the

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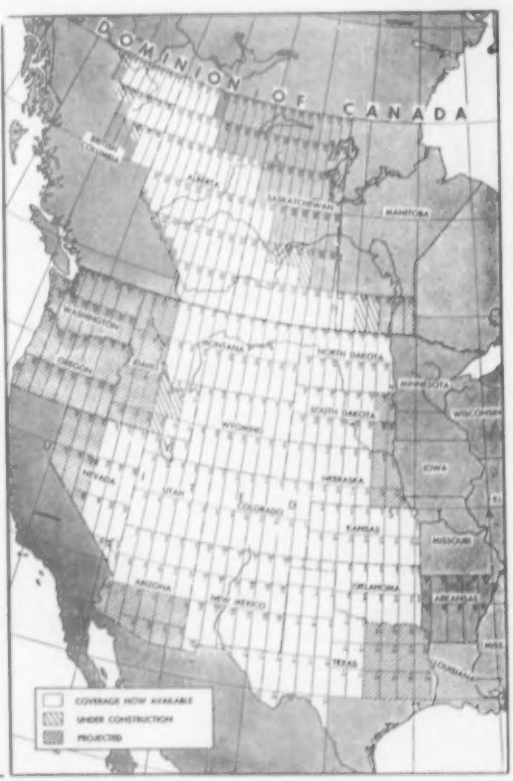

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thickening is most noticeable in the case of the Lower Cretaceous. The Raritan formation is marine from Salisbury eastward, while the presence of some Lower Cretaceous fossils in the well at Ocean City shows that parts of the basin were covered by the sea during early Cretaceous time. Because of the great thickness of the Cretaceous beds in wells at Berlin (3,400 ft.) and Salisbury (3,000 ft.), it is believed that this trough represents an ancient estuary, possibly the ancestor of Chesapeake Bay or the Potomac River.

A significant feature of the Salisbury embayment is the presence of Triassic sandstone and shale beneath the Cretaceous sediments and on top of the basement. These Triassic sediments thicken to the seaward and may represent a basin or graben similar to the other Triassic basins along the Atlantic Coast between Nova Scotia and Georgia.

Thus the Salisbury basin may have been downfaulted during Triassic time and then filled with estuatine sediments throughout much of the Cretaceous. It is possible that the Triassic basin may have extended eastward to the sea and that there might be marine Triassic sediments east of the present shoreline. However, no marine Triassic fossils have been reported from any of the wells in the embayment. (The well at Ocean City stopped in the Cretaceous above the Triassic contact.)

An unsuccessful oil test was drilled at Isle of Wight, Worcester County, in 1914 to a depth of 1,706 ft. A few years later (1918), St. Martins Oil & Gas Co. drilled a test at Parsonburg, Wicomico County, which was abandoned in the Miocene at 1,186 ft. Gas was reported at 35 ft. and gave rise to considerable speculation that there might be deeper finds of oil or gas. It is reported that the gas was used locally for a few months; however, it was probably marsh gas of no commercial significance.

Another test drilled at Meadows, Prince Georges County, only 6 miles from the District of Columbia line was noteworthy for its 1,500-ft. section of Lower Cretaceous. The well was abandoned, dry, at 1,506 ft. at or near the contact with the basement. Since the bedrock crops out only a few miles to the west in Washington, this indicates a dip of about 125 ft. per mile. This may mark the landward limit of the Salisbury embayment.

Most of our knowledge of the subsurface geology of the Eastern Shore, especially of the Salisbury embayment, has come from three important test wells drilled between 1944 and 1946. These are Ohio Oil Co.'s Hammond, near Salisbury, Wicomico County (total depth 5,529 ft.), Socony-Vacuum's Bethards, near Berlin, Worcester County (total depth 7,157 ft.), and Esso Standard's well near Ocean City, Worcester County (total depth 7,710 ft.).

The only recent attempt to find oil in the Coastal Plain of Maryland has been a shallow test well drilled in 1955 near Pomonkey in Charles County on which no information is available.

On the other hand, considerable new information on the subsurface geology of the state has been obtained by the Department of Geology, Mines and Water Resources, in connection with ground-water studies, and by some test wells drilled in Prince Georges County in 1955 and 1956 for Washington Gas Light Co. in the hope of finding a possible structure for the storage of natural gas. It is reported that Triassic beds underlie the Cretaceous sediments in this area.

Virginia . . . Upper Cretaceous deposits are relatively thin in the Coastal Plain of Virginia. Sediments of the Monmouth-Matawan apparently pinch out between the Salisbury embayment and the Virginia Capes, while the Raritan is limited to a 70-ft. section in wells near Norfolk. Nonmarine sediments of the Potomac group underlie the Raritan in the Norfolk wells and crop out over a wide area.

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Deposits of Eocene and Miocene age overlie the Cretaceous and occur on the surface in many places. Most of the outcropping Eocene deposits are regarded as belonging to the Aquia and Nanjemoy formations of Lower and Middle Eocene age, while in the subsurface and possibly locally in outcrops, formations of Paleocene and Jackson age have been recognized.

The Eocene is somewhat thicker north of the James River than south of that river. According to D. J. Cederstrom, this may represent a fault; another interpretation is that this marks the southern edge of the Salisbury embayment, or possibly another embayment of similar origin.

The basement rock is relatively near the surface in the region of the Virginia Capes, having been encountered at only 2,246 ft. in a water well at Fort Monroe, and forms what is sometimes spoken of as the Fort Monroe High. As shown by geophysical work, basement dips at a rate of about 30 ft. per mile from Petersburg to the coast, greatly increasing its dip beyond this point so that at a point about 60 miles offshore it is at a depth of about 12,000 ft.

The only significant oil test in the Virginia Coastal Plain was one drilled by Elkins Oil & Gas Co. at Matthews in 1929. Traces of gas in the upper strata led to the drilling of the well. However, as in the case of the Parsonsburg well in Maryland, the gas was probably surficial marsh gas.

A recent report of an oil seep near Newport News was without confirmation.

North Carolina . . . In an article published in 1947, the author made the statement that "the region between the Virginia Capes and Cape Hatteras is the biggest question mark, geologically speaking, along the East Coast." At the present time only part of this question mark may be erased.

It has been known for sometime that the basement dropped decidedly between the Virginia Capes and Cape Hatteras. This was clearly demonstrated by Esso Standard's well at Cape Hatteras which reached basement at 9,878 ft. in contrast to the presence of basement at Fort Monroe at 2,246 ft. Published geological and geophysical maps suggested that the dip was rather uniform without any major structures. This idea was somewhat exploded in 1953 by the drilling of a well by the duGrandlee Exploration Co. some 10 miles north of Elizabeth City. All indications pointed to the presence of basement at about 3,600 ft.; however, after penetrating Tertiary and Upper Cretaceous sediments, the well passed into a thick (650 ft.) section of green cherty dolomite of unknown age (Lower Cretaceous ?) underlaid by red shales and diabase presumably of Triassic age. Basement rock had not been reached when the well was abandoned at a depth of 6,421 ft.

This well has been interpreted as indicating the presence of another Triassic basin or graben, somewhat similar to the Salisbury embayment, under northeastern North Carolina. While this well may have filled in part of the gap between the Virginia Capes and Hatteras, it has presented additional unsolved problems, mainly regarding the extent of this basin.

Basement rock continues to drop toward Cape Hatteras, and as indicated above, occurs at 9,878 ft. at that cape. A thick section has been recognized in the Esso Standard well consisting of Tertiary, Upper and Lower Cretaceous, and Jurassic, but with no Triassic.

Basement rock as well as all overlying formations rise between Cape Hatteras and Cape Fear, forming what has been regarded as one of the most conspicuous structural features of the Atlantic Coast — the so-called Great Carolina Ridge or the Cape Fear Arch. At Wilmington, basement rock is as close to the surface as 1,109 ft., and

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then drops off again toward South Carolina.

The basement slopes rather gently (about 10 ft. per mile) from the Fall Line toward the coast, but from a line near Beaufort eastward, it increases considerably indip attaining a dip of more than 100 ft. per mile to Hatteras. However, recent exploratory wells in Cartaret, Craven, Pamlico counties and elsewhere have shown that there are numerous "hills." In fact, at least two of these hills extend above the surface cutting the Tertiary deposits at Smithfield and Fountain.

The Cretaceous deposits are overlaid by Eocene, Oligocene (known only from the subsurface), Miocene, and younger deposits. That the Eocene seas extended some miles beyond the Fall Line is shown by the finding of Middle Eocene marine fossils near Raleigh and elsewhere in the Piedmont.

Although there were several early test wells drilled in the Coastal Plain of North Carolina, the first significant tests were two wells drilled by Esso Standard in 1946 and 1947 at Cape Hatteras and in Pamlico Sound respectively. As has already been mentioned, the former well encountered basement at 9,878 ft. and stopped in granite at 10,006 ft.; the latter well was abandoned at 6,329 ft., still in the Cretaceous. The fact that these exhaustive tests did not yield any signs of oil or gas has had a discouraging effect in the area.

Nevertheless some 20 wells have been drilled between 1945 and 1955, mostly by Coastal Plains Co. and Carolina Petroleum Co. Although newspaper accounts have reported a few shows of oil or gas, no commercial production has been obtained. The deGrandlee well north of Elizabeth City, mentioned above, showed some gas, but information on its nature and quantity are not available.

South Carolina . . . The geology of South Carolina is very similar to that of North Carolina. Basement drops to the south of the Great Carolina Ridge and the various overlying formations thicken accordingly. The Cretaceous is represented by the Tuscaloosa which is marine downdip but largely nonmarine in outcrop, and by the overlying Black Creek and Peedee, both largely marine. The Tertiary section is very similar to that of North Carolina, except that the Oligocene is represented by outcrops as well as subsurface deposits. The best section of the Coastal Plain of South Carolina is shown by a 3,434-ft. water well at Parris Island.

Wells at Florence and Summerville have penetrated what is regarded by some as a Triassic basin, possibly similar to the ones farther north in North Carolina and Maryland. However, since no samples are available from these wells, the presence of this basin must be regarded as unproved, although geophysical work of McCarthy, Straley, and others tends to support this interpretation.

Oil tests in South Carolina have been limited to a few relatively shallow wells mostly on the southern flank of the Great Carolina Ridge.

Georgia . . . The basement as well as the overlying Cretaceous and Tertiary deposits continue to dip southward along the coast from South Carolina to the Florida line. All of these formations from basal Upper Cretaceous (Tuscaloosa) to Pleistocene outcrop on the surface.

There is an indication of a slight ridge in the basement some 90 miles inland from the coast (Atkinson County) and then a decided dip to the southwest toward the Alabama state line. The Tulscaloosa thickens in this basin and becomes more marine as shown by several oil tests in Dougherty and Crisp counties. Nonmarine Lower Cretaceous underlies the Tuscaloosa in several wells in this basin and this formation also thickens toward the southwest. Although no Jurassic sediments

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have been found under Georgia, they have been recognized in deep wells in Clarke County, Alabama, and it is possible that they may extend eastward into Georgia.

Some of the Georgia test wells have bottomed in sandstones, shales or igneous rocks of Paleozoic or Triassic age, so it is apparent that deposits of pre-Cretaceous lie on top of basement in some parts of Georgia. Although more oil tests have been drilled in Georgia than any Coastal Plain state to the north, the samples have not been completely studied, and it is therefore impossible to adequately map the subsurface of that state.

Some 80 test wells have been drilled in the Coastal Plain of Georgia, of which all but 14 were completed subsequent to 1938. Although none of the tests have produced commercial oil or gas, interest is still relatively high, largely because of the discovery of oil in recent years in Alabama.

Florida . . . Although Florida will not be fully discussed in this article, a few words of summary might not be out of order.

The surface geology of the state includes formations dating from the Middle Eocene (Avon Park limestone) to the Recent. Oil tests have penetrated rocks of earlier Eocene, Upper and Lower Cretaceous, and older age. The northern part of the state is characterized by the Peninsular Arch and the Ocala Uplift and the southern part by the South Florida embayment.

In the former area wells have penetrated Ordovician and Devonian sandstones and shales beneath the Lower Cretaceous beds, while in the southern part of the state, the Cretaceous sediments are very thick and have not been completely penetrated. Sunniland oil field produces from a depth of 11,613 ft. in limestones of early Cretaceous age (Trinity?). This field with its 16 producing wells has yielded some 4,500,000 bbl. of oil. The 40 Mile Bend field, located some 28 miles west of Miami and abandoned in 1956, produced approximately 33,000 bbl. of oil.

Conclusion

Although it is not the purpose of this paper to suggest locations for further drilling, it might be well to conclude by listing a few places where further drilling might be desirable.

1. **Southern New Jersey.** The section here is several thousand feet thick and probably largely marine as shown by recent test borings in Ocean County.

2. **Salisbury embayment of Maryland.** Even though previous tests were negative, the considerable thickness near the coast should warrant further exploration.

3. **Northeastern North Carolina.** Exploration of the basin found under the Elizabeth City area seems justified.

4. **Southwestern Georgia.** Although numerous wells have been drilled in this area, exploration possibilities are by no means exhausted.

5. **Offshore.** Certain shallow shoals up to 15 miles off the coast between New Jersey and the Carolinas will probably some day deserve attention.

6. **Florida.** Not considered in this paper.

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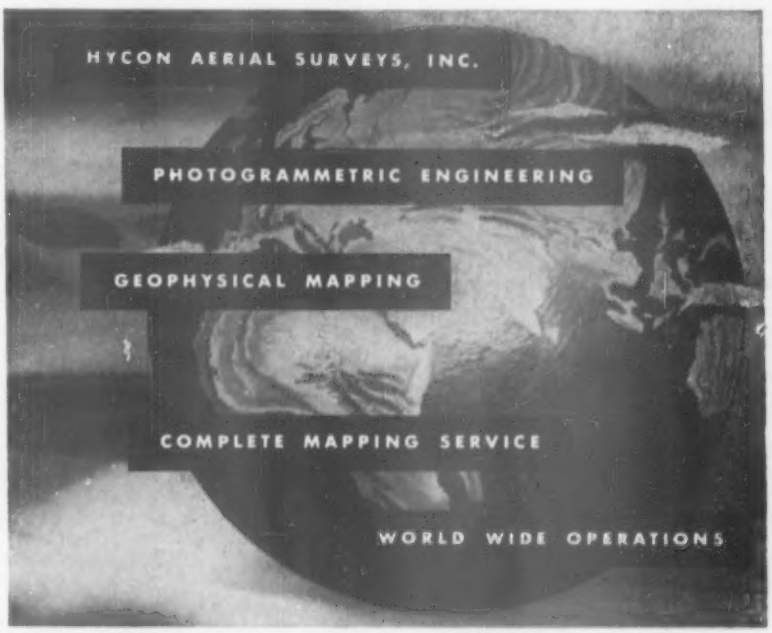

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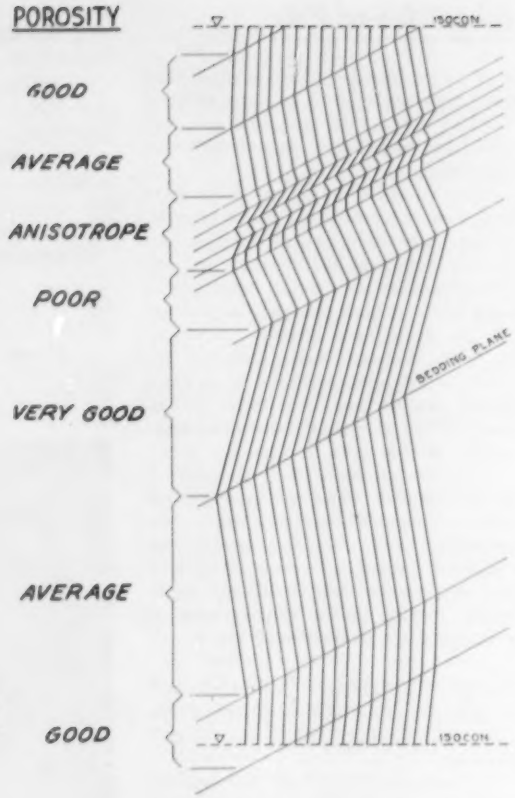
What causes

Low Radiation Intensities . . .

over oil fields?

by Hans Lundberg



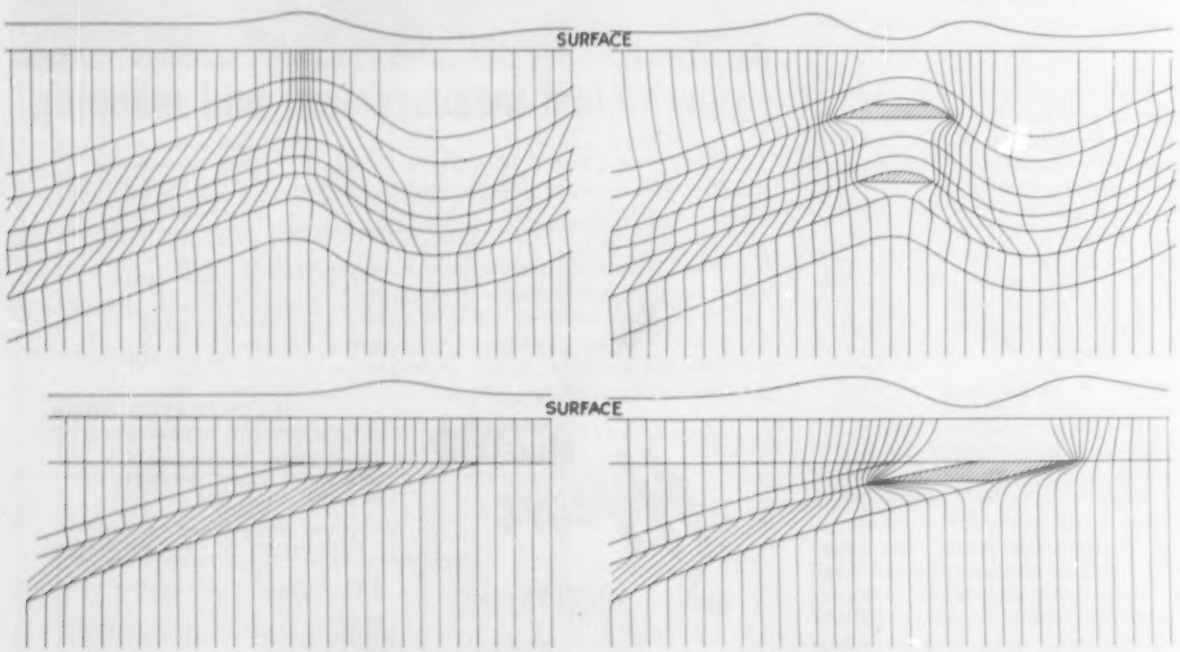
MOVEMENT of connate waters as related to the altitude of bedding and isocon surfaces. Fig. 1.

TO produce a true map of the radiation pattern on the earth's surface the instruments must have a high counting efficiency and the recordings must be made at optimum altitude and integrating time. While the outlining of bodies of uranium or thorium ore is comparatively easy, the interpretation of the radiation into terms of oil or gas accumulations is a complex process. This is because the effects of topography, drainage system, and geological features must be eliminated before any such interpretation can be made of the residual radiation pattern.

Three or four feet of water prevents any radiation from reaching the instruments in the aircraft, so lakes and bodies of water will show up on the recorded radiation pattern as outstanding lows. Since small rivers and tributaries, which sometimes are dry, also cause lows on the radiation pattern, we have assumed this to be caused by the eroding effect of the running waters which, during wet seasons, carry away the radioactive substance at the surface.

Author is president, Lundberg Explorations, Ltd., Toronto.

Working hypothesis and interpretation . . . The theory that oil accumulations



DEFLECTIONS of upward flow with and without oil accumulation. Fig. 2.

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Low Radiation Intensities

reveal their presence at the surface is still controversial. In too many cases, however, new oil fields have been revealed and the characteristic pattern found over known fields for this to be coincidence only. Therefore, a reasonable explanation must be sought.

Our working hypothesis is intimately linked together with the migration of the waters in deeper formations, as well as with the processes involved in accumulation of oil. As these problems are complex and we still know so little about the movement of the waters, the following is offered as a contribution to help ferret out the path of the deeper waters.

Rocks are composed of mineral grains packed or arranged in different patterns. At depth the space between the grains is normally filled with liquid. Now, one must assume a drive that results in the upward movement of the waters.

There is a very close resemblance between the flow of liquid through the rock formation and the flow of electrical current in the ground.

Rock minerals are electrical insulators so it is the water in the pores between the mineral grains that makes the rocks conductive to electric current. In other words, water and electric current must follow the same path through the rocks. By model experiments the flow of electrical currents across the formations may be traced and studied in detail by applying suitable potential differences corresponding to the pressure differences in the ground. In this analogy it should be remembered that while the electric currents move fast, the water movement is very slow, perhaps less than a quarter of an inch a year.

A dense cap rock may hold considerable water by having high porosity but, at the same time, have low permeability. Electrically these shales show higher conductivity parallel to the bedding planes than in a perpendicular direction. Such anisotrope conductivity, which is characteristic for most bedded, fissile, and schistoid rocks, is analogous to the low permeability so often found across the bedding in a dense cap rock.

From the orientation of the isocons (lines of equal salt content), it would appear evident that the regional upward flow is unimpeded by structure and lithology.

While the movement is even and parallel in homogeneous rocks the great variety of porosity and permeability encountered in the different beds may cause the water to flow faster through one rock than another, resulting in local deflection of the movement. Anisotrope condition caused by low permeability

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or conductivity in certain directions may also divert the flow locally. It must be remembered that the amount of deflection in the movement also depends on the angle at which the flow reaches a bedding plane or contact between different rocks. Fig. 1.

Unless there is a channelway leading to the surface it would seem quite impossible to have a lateral movement take place along one bed as this would upset the regional balance. Therefore, any apparent lateral flow must be the integral movement of a local deflection in the regional upward migration.

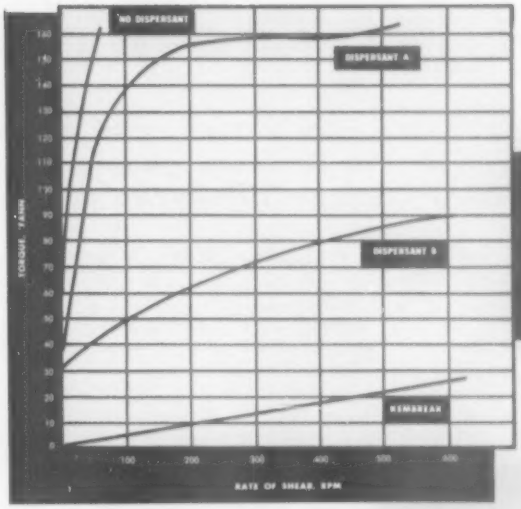
Pressure differences and the extremely fine pores through which the movement has to pass may cause changes from one bed to another in the composition of the water.

Diversion of flow . . . Examples shown on Fig. 2 give an idea of how a flow may locally become diverted by anticlines or stratigraphic conditions.

The converging flow into the reservoir rock is slowed down under the dense cap rock where, under suitable conditions, oil may be precipitated, separated from the water, and gradually accumulated. After an oil pool has been formed under the cap rock, the flow from below is locally diverted so that little or no water will reach the surface directly above the oil accumulation, as shown in Fig. 2.

Chemical changes . . . The composition of the water undergoes changes by being in contact with the oil. Originally of both chloride and sulfate character, the presence of hydrocarbons will reduce the sulfates to sulfide, so that the water escaping upwards at the edges of the oil field would be fairly sulfate free. Now this chloride-containing water may dissolve radium and other metals from the rocks passed through, and carry them in dilute solution toward the surface where the insoluble sulfates are precipitated in a pattern that will reflect conditions below.

Assume now that the water brings small amounts of salt to the surface, where it is precipitated as insoluble sulfates, then more salt will be accumulated where the water flow is most abundant. In Fig. 2 the proportionate amounts of salt brought to the surface shows the content to be high over the edges of the oil field and low over the oil where, before accumulation, high salt content existed. Fortunately we have instruments now that can reveal the presence of minute amounts of such elements as radium which, among others, has insoluble sulfate. Therefore, with this radioactive recording and mapping, a rapid tracer technique has been developed that is many hundred times more sensitive than any chemical analysis.



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What Is a Gravity Anomaly?

The authors here give a number of definitions, based on their meanings to different people, and then tell how to reproduce them artificially, to determine their causes

by R. A. Geyer and Frederick Romberg

WHAT is a gravity anomaly? To get a complete answer, it is necessary to consider not only the definition of the word, but also the fundamental factors of geology and physics. But the first reaction, in anyone who asks himself the question, depends on the timing, the professional interest, the experience, and the responsibilities of the individual.

The exploration manager—the man responsible for selecting well locations or buying acreage—will probably think of a gravity anomaly primarily as an aid in reaching a decision. The field geologist or geophysicist, charged with conducting an exploration program, may think of a gravity anomaly as a guide in planning and executing action for the short or the long term. To the geodesist and the academic geologist a gravity anomaly may mean something entirely different. It can be the number, or set of numbers, which results from a long chain of reasoning and observations—a clue to the shape of the earth, or to the major features of the earth's crust, or to buried basins and mountain ranges.

But the meaning which "gravity anomaly" has for everyone is that of something unknown or unpredicted in the gravity map—an irregularity not accounted for by the known geology, a piece of evidence showing that our picture is incomplete.

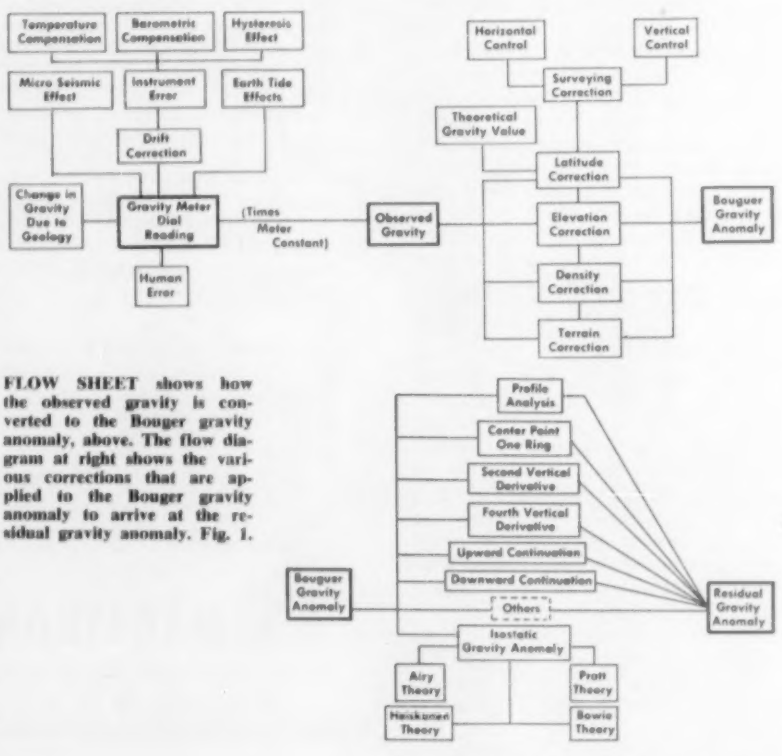
Anomalies . . . It is true that the meaning of the word "anomaly" has been extended to take care of features in the gravity map which are now perfectly well known but are still irregular from the standpoint of some system. For instance, the isostatic anomaly of a gravity station is the difference between the observed value and what the value would be if the mountains in the neighborhood were in what is called isostatic equilibrium—that is, if the mountain roots were floating in the heavier plastic material of the earth's crust the way we think they should. The fact that we know this difference for a given station, and have measured it accurately, does not mean that we know its cause or could predict it for a station in a new area.

Such an isostatic anomaly may be larger than 200 milligals, and extend over thousands of square miles. At the other end of the scale, the anomaly due to a small fault near the surface, or a minor body of iron ore, may amount to no more than two or three-tenths of one milligal. But, in common with its larger brother, it is irregular and unknown. On the gravity map it is a break in a surface that was previously thought to be regular.

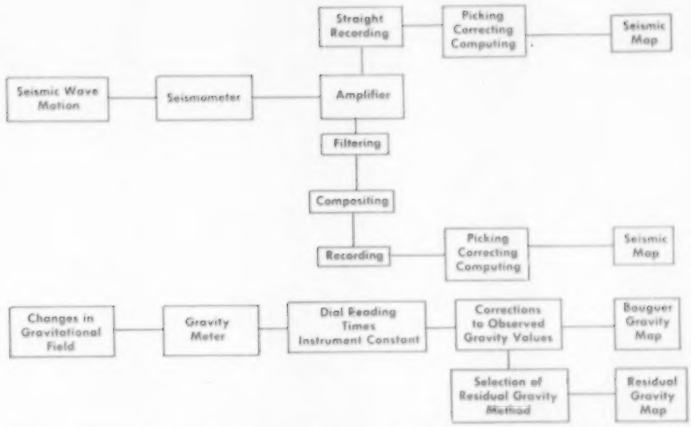
There are, of course, anomalies inside other anomalies. A closed low of four or five milligals, in an unexplored area of the Texas Gulf Coast, used to mean that there was probably an unknown salt dome beneath it. Then, after the salt dome was discovered by the drill the low was no longer, strictly speaking, an anomaly, though it had been one. But an unexplained bulge in the contours, after detailed work was done, might be an anomaly in itself, and perhaps turn out to be due to an undiscovered overhang or extension of the dome.

Kinds of gravity anomalies . . . The fact that the words "gravity anomaly" have different meanings to different people is of course connected with the fact that gravity anomalies have different geological meanings. In order to understand these different meanings it is helpful to trace out what happens between the time a gravity meter is set up on a station and read, and the final posting of a value on a map. Two "flow sheets," similar to the flow sheets for a product or process in business, have been set up to illustrate this. The first flow sheet (Fig. 1) is a meter flow sheet, showing the process from field station to Bouguer anomaly, often called the "raw gravity." The Bouguer (pronounced boo-gay) anomaly is the difference between the observed gravity and the value which gravity ought to have if the rocks underneath the station were in horizontal layers and had the predicted average density.

A variation from the predicted value of gravity means, then, that there are



FLOW SHEET shows how the observed gravity is converted to the Bouger gravity anomaly, above. The flow diagram at right shows the various corrections that are applied to the Bouger gravity anomaly to arrive at the residual gravity anomaly. Fig. 1.



THE VARIOUS TYPES of gravity maps can be compared to the different types of seismic maps. Fig. 2.

some rocks present whose densities are different from what we thought they would be, and which therefore constitute some kind of "anomalous" geological feature. Before the Bouguer anomaly can be figured out, however, a crowd of other anomalies have to be taken into account and correctly computed. These are shown on the meter flow sheet; they can be divided roughly into effects within the meter, such as instrument error, and effects outside the meter, such as anomalies due to rough terrain, changes in elevation and surface density, and earth tides.

When the observed gravity is "operated on" by all these effects and corrections, and compared with what gravity ought to be if everything were smooth, the result is the Bouguer anomaly. This, of course, has the value we think it has only if all the preceding anomalies have been correctly measured and predicted.

It is the Bouguer anomaly which is the basis of study of all the other different kinds of anomalies which are used by theoretical or applied geophysicists. The second flow sheet (Fig. 2), which is called the anomaly flow sheet, illustrates this. The geodesist takes the Bouguer anomaly and applies a correction to it which is derived from one or the other theories (the Pratt theory, the Airy theory, or modifications of either) to arrive at his isostatic correction. While this is primarily of interest to scholars, the practical geophysicist finds himself much concerned with it when he is near a mountain range and his Bouguer map begins to tilt sharply.

But even when he is on the plains,

Gravity Anomalies

THE AUTHORS

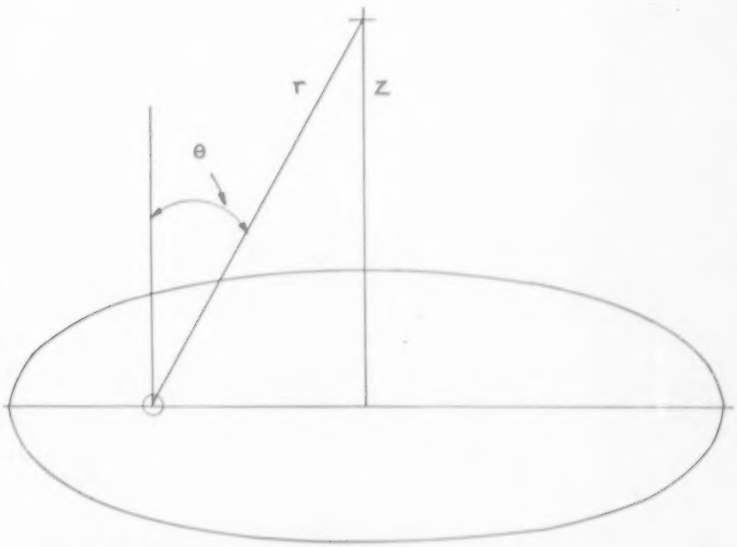
R. A. GEYER

F. E. ROMBERG

Dr. Richard A. Geyer is now chief geophysicist, gravity department, Geophysical Service, Inc., Houston. Beginning in 1946, he was engaged in the coordination of geophysical research in the exploration department of Humble Oil & Refining Co. During this period he did special work in connection with oceanographic engineering problems, and served as chairman of the wave-force research committee of the offshore operators committee. He has been a part-time faculty member of the department of physics and geology of University of Houston since 1948, instructing in geophysics and marine geology; and was editor of Geophysics from 1949 to 1951. He is a graduate of Princeton University. He is a member of the S.E.G. and A.A.P.G.

Frederick Romberg is manager of the gravity department of Geophysical Service, Inc., Houston. He received his B.A. degree from University of Texas in 1927, and his A.M. from Harvard in 1932. He spent the year 1929-30 in the geophysical department of Humble and the years 1933-41 as computer and party chief, and in the study of computing techniques, with Geophysical Service, Inc. From 1941 to 1951 he worked on manufacture and development of gravity meters with LaCoste and Romberg. In 1951 he rejoined Geophysical Service, Inc., as southern division manager. He is a member of S.E.G., the European Association of Exploration Geophysicists, the American Geophysical Union, and the Geological Society of America.

THIS NEW ANALOG computer operates on the principle that light from an extended source can be represented by an expression which is the same as that for gravity except for the depth factor. Fig. 3.



Cos $\theta = z/r$ where θ is the angle between the vertical and the line joining (x, y) to the origin; x, y, and z are cartesian coordinates with z denoting the vertical plane. Fig. 4.

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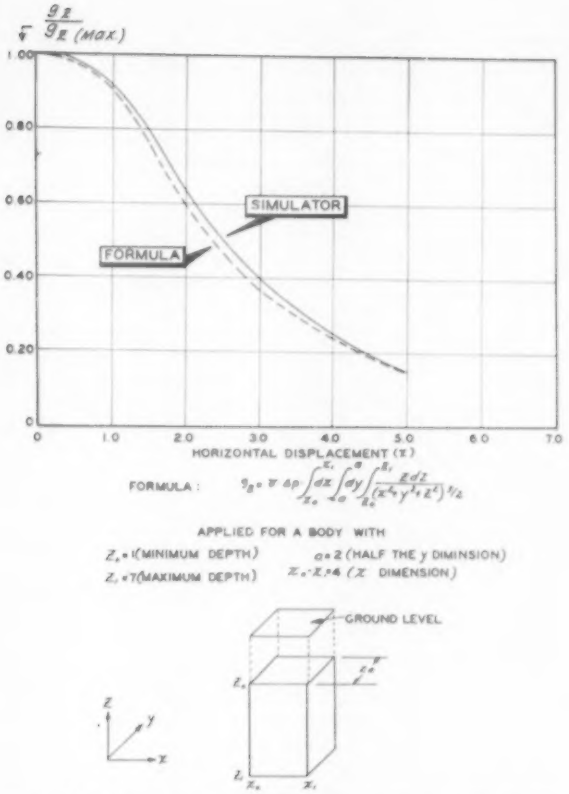
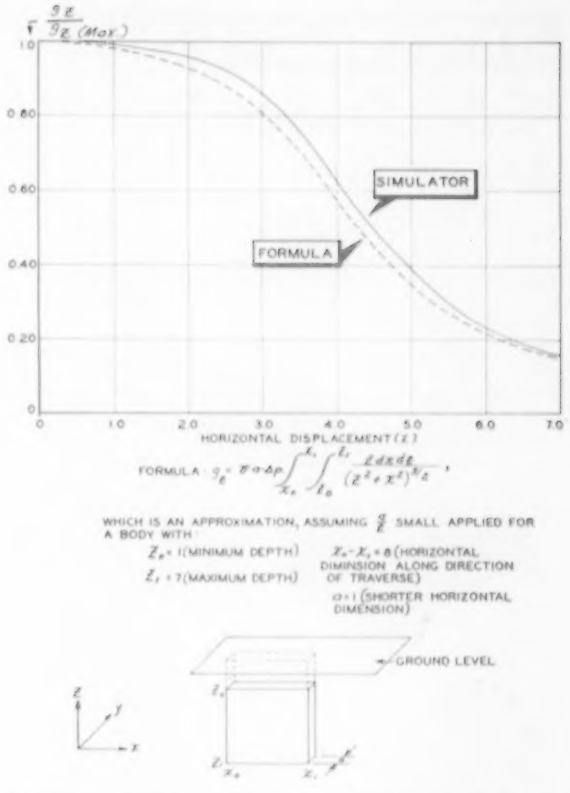


NOTICE that the values determined by the gravity anomaly simulator agree very closely with values arrived at by use of formula. Fig. 5.


SIMULATOR
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FORMULA :
WHICH IS AN APPROXIMATION, ASSUMING $\frac{a}{z}$ SMALL APPLIED FOR A BODY WITH :
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$X_1 - X_0$ = 8 (HORIZONTAL DIMINSION ALONG DIRECTION OF TRAVERSE)
a = 1 (SHORTER HORIZONTAL DIMENSION)
GROUND LEVEL

AGAIN the simulator reproduces a curve that is nearly identical with the curve arrived at by using the formula. Fig. 6.

Gravity Anomalies

the exploration man uses the Bouguer anomaly as a basis for computing a number of different kinds of corrections which will leave him with his final product, a map of the residual anomaly. The flow sheet gives the names of several methods for arriving at a residual anomaly; each interpreter has his favorite, but they all have in common the object of producing a residual anomaly which can be interpreted as **evidence for or against the thing he is looking for.**

Treatment of residual anomalies . . . It is here that one of the most important and most misunderstood points of the art of interpreting anomalies needs to be emphasized. The information which goes into making up the Bouguer anomaly is all basic and depends on physical facts which are, or ought to be, observable. The devices for operating on the Bouguer anomaly in order to get a resdual anomaly are all steps of logic rather than fact. They may make the Bouguer anomaly easier to understand but they cannot put anything into it which is not already there.

The information which the residual anomaly chooses to emphasize depends on the size of template or radius used and on the treatment of the station values chosen; if this size is well chosen, and the treatment logical, the anomalies which the interpreter then sees will be closures or trends related to the kind of geology he is interested in. If not, there is always the danger that the anomalies do not represent subsurface geology, but only the errors inherent in readings and corrections, emphasized by a residual method that was too fine for their original accuracy. However, there is no doubt that the different kinds of residual anomalies are useful in analyzing gravity maps for features which are not apparent without critical study.

Importance of geological thinking . . . What a gravity interpreter needs to keep in mind, as he studies the anomalies on his maps, is the fundamental fact that a gravity anomaly, as such, has no meaning until it is associated with at least some geologic information. In this, gravity interpretation is different from interpretation of seismic data. The seismic computer takes numbers from a record and plots them as depths and dips on a cross-section. The cross-section represents geologic structure (except in cases like multiple reflections) and could be plotted by a person (or a machine) who knew no geology at all.

But a gravity anomaly, unlike a seismic depth or dip, can theoretically be caused by an infinite number of different geologic configurations. It is only when the interpreter knows something about the geology of the area he is studying that he can really make the connection between an observed anomaly and the kind of geologic feature which may be its cause. No automatic or theoretical treatment of gravity will do this for him.

Connecting gravity and geology . . . The crucial point, then, in interpreting gravity data is not the construction of the residual anomaly but the setting up of a relation between it and geologic structure. This problem cannot be worked in a forward direction; that is, the gravity anomaly cannot be turned into a geologic feature. The problem has to be worked by imagining a geologic feature and computing its gravitational effect. If this looks like the observed gravity then it is possible that the geologic feature may exist as we have imagined it. But if not, we must try again.

Finding the gravity of a known or imagined geologic feature is a tedious process if it is done mathematically, so a number of tricks have been invented to make it easier, such as nomograms, dot charts, and graticules. However,

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Gravity Anomalies

these devices are still so slow that the interpreter has to abandon a problem before he has really tried out all the different geological features he can think of as possibly causing the anomaly he is studying. A better solution to the problem would be an analog computer, and a good many approaches of this kind have been tried. A recent analog computer will be described below.

Gravity Anomaly Simulator

The new analog computer, shown in Fig. 3, is based on the principle that light from an extended source can be represented by an expression which is the same as that for gravity except for the depth factor. However, this factor can be included by raising or lowering a photocell that detects or measures this light.

The basic mathematical considerations involved in the design of this instrument include the equation for the contribution to the vertical component of gravity of an arbitrarily shaped body:

$$g_z = \gamma \Delta\sigma \int dx \int (z/r^3)\, dx\, dy \quad (1)$$

where:

γ = gravitational constant (gamma)
$\Delta\sigma$ = density contrast between the body and the surrounding material
x, y, z = cartesian coordinates with z denoting the vertical plane

The origin is taken at the point where g_z is the gravitational contribution, and the integration is taken over the entire body.

Although Equation 1 is exact, it is difficult to apply to any practical shape that might simulate anything but the simplest geologic structures.

However, by dividing the body into horizontal layers of finite thickness, dz, Equation 1 can be modified to the form shown in Equation 2:

$$g_z = \gamma(\Delta\sigma)(dz)\,Zo \int (1/r^3)\, dx\, dy \quad (2)$$

and the integration performed over the top surface of each layer. This modification has the advantage that the remaining integral can be solved by an analog method. This analog is the illumination at a point, namely the origin, in the vicinity of a horizontal luminous surface which obeys Lambert's cosine law. This law can be written in the form of Equation 3:

$$L = K \int (\cos\theta/r^2)\, dx\, dy \quad (3)$$

where:

θ = angle between vertical and the line joining (x, y) to the origin
K = luminous flux per unit area per unit solid angle

It is evident from Fig. 4 that $\cos\theta = z/r$. Therefore, Equation 3 can be written in the form:

$$L = K \int (z/r^3)\, dx\, dy \quad (4)$$

Equation 4 is now in the same form as the gravitational integral for a horizontal layer.

The results of a comparison between values calculated from Equation 1 and by using the gravity anomaly simulator are shown in Figs. 5 and 6.

The trend of the various comparative measurements indicated that the maximum depth did not affect the accuracy. However, to keep within 5 per cent the difference between calculated values and those obtained with the instrument, the ratio of the minimum depth to the maximum horizontal dimension should not be less than one to four.

Conclusions . . . In conclusion, it can be stated that the Bouguer gravity anomaly results from the application of a number of corrections to the gravity meter dial reading. The application of many of these corrections involves the personal judgment of the experienced gravity operator and computer. The "raw gravity" or Bouguer anomaly map can then be operated on by any number of empirical processes to obtain a residual gravity anomaly.

An effective evaluation of a Bouguer or residual gravity anomaly cannot be made in a unique manner because many different geological situations can develop the same type of anomaly. It is extremely important, therefore, for the gravity interpreter to be as fully apprised of the geological conditions as possible.

Several different sets of subsurface conditions can develop the same gravity anomaly. It is a difficult and laborious process to compute the gravity anomaly resulting from each type of subsurface anomaly through conventional means. Through the use of an analog computing device, such as the gravity anomaly simulator, it is possible much more readily to determine the relationship between a theoretical or hypothetical anomaly and the observed anomaly. This technique, combined with improvements in the accuracy of field measurements, more widespread use of rock density data, and the synthesis and integration of available geological as well as other forms of geophysical information, will greatly increase the effectiveness of gravity surveys as a geophysical prospecting method.

California Looks to The Sea

. . . and sees offshore drilling as its bright hope for the future

by William T. Smith
District Editor

ANY discussion of exploratory trends in California must logically start with the offshore possibilities. That isn't to preclude any future developments onshore, but it's generally conceded that the hope of California for future production of significant quantities of crude lies offshore.

Prior to passage of the Cunningham-Shell Act last year, tidelands development in California was confined to areas in danger of being drained by offsetting production, or in cases where specific cities had title to their own tidelands.

The new act opened up some 135 miles of potentially rich tidelands to exploration and development on a bonus bidding basis. Virtually all the tidelands involved offsets major producing areas onshore.

However, the machinery set up under the act for awarding tideland leases is geared to move slowly. Best estimates are that a minimum of 200 days will be required to just process applications. Up to this writing, the State Lands Commission has received requests for bonus bidding on tideland parcels involving some 89,200 acres. However, no leases have been awarded as yet under the new law. Further, because of the time element, it is unlikely that any tideland leases awarded this year will be productive before next year.

There are a number of tideland operations now under way on leases awarded prior to the Cunningham-Shell Act. In all cases, these leases were granted when there was danger of state or city tidelands being drained by neighboring production. Two of the more interesting of these tideland exploratory operations include:

Rincon . . . Richfield Oil Corp. has called for bids for construction of an earth-filled island on its 1,175-acre lease offshore from Rincon field, Ventura County. This action followed a four-hole coring program. The last core test Richfield drilled on this lease was actually completed from its drilling barge for a successful 6-hour test. The first island will be built on a site ½ mile from shore in 45 ft. of water. It will be 200 by 200 ft. in size above the water level.

Redondo Beach . . . The other tideland exploratory program now under way which is attracting widespread attention is the one being carried on by Signal Oil & Gas Co. at Redondo Beach. Here Signal, acting as operator for itself and two other companies, was drilling a slant-hole test from an onshore site in the city limits of Redondo Beach. Signal has reported three good drill-stem tests on this well already.

CALIFORNIA'S HOPE for important future oil production rests with its offshore possibilities. Known producing trends apparently extend into the offshore waters, making these areas of prime interest to oil men.

Under terms of the agreement, Signal will be allowed to complete six wells from the single onshore site with future development wells to be drilled from an island beyond the breakwater.

Orange County . . . No discussion of tideland exploratory operations in California would be complete without considering the situation in Orange County. Here are found tidelands bordering some of the most productive fields in the state. The rich potential of these tidelands has been quickly recognized by operators who have petitioned the state to open for bidding some 9,000 acres lying between Huntington Beach on the south and Long Beach to the north.

This area will see the first gulf-type drilling platform to be used on the West Coast when Monterey Oil Co. takes delivery of a Delong-type platform in July. Monterey will use the drilling barge to conduct a core-hole exploration of a 1,280-acre lease located a mile offshore from Huntington Beach. This lease is jointly held by Monterey, Humble Oil & Refining Co., and Seaboard Oil Co.

Long Beach . . . Recent settlement of the long-standing dispute between the state and Long Beach over tidelands revenues cleared one hurdle to exploration and development of tidelands between Long Beach and Monterey Oil Co.'s offshore island at Seal Beach. Seismic work indicates the prolific Wilmington-Torrance anticline extends the 4½ miles between present Long Beach tideland production and Seal Beach.

Onshore Trends . . . Exploratory activity onshore in California will most likely be highlighted by two developments in San Joaquin Valley and four in the Coastal region.

One area which has been the scene of considerable exploratory drilling in recent years, and which continues to turn up excellent pays, is at Wheeler Ridge in southern Kern County.

Richfield last year scored three good finds at Wheeler Ridge. One was 2 miles southwest of regular Wheeler Ridge field production where Richfield completed an 11,000-ft. wildcat for Eocene production. The other two were new-pool discoveries on the north and northeast flank of Wheeler Ridge field.

In early March of this year, Richfield chalked up another major discovery in this region with a wildcat located 2 miles southeast of Wheeler Ridge field. This successful test was completed in a Miocene formation. It is probable that Richfield will now test for Eocene in the first offset to this discovery. In addition, Richfield has staked a wildcat location more than 2 miles north of this latest discovery.

These successes pinpoint this area as one sure to get a thorough exploratory drilling program this year.

The other San Joaquin Valley region

California Exploration

slated for considerable exploratory activity is the Strand field area of Kern County.

Last year Shell Oil Co. turned up three new Stevens zone pools and a major discovery in the deeper Vedder zone in the Posuncula area. Again, this type of successful exploratory work promises plenty of activity for this area in 1956. The first big extension test of this new production will be drilled by Union Oil Co. on a site more than a mile northwest of the discovery area. Union's wildcat will probably test both the Stevens and Vedder zones.

Coastal region . . . In the coastal region of the state, four areas stand out as the top prospects for development and exploratory work in '56.

The present demand for heavy crude will result in renewed development programs at both San Ardo and Guadalupe fields in Monterey County. The former is fully developed but General Petroleum Corp. and The Txas Co. are carrying out an infill program in the Lombardi zone, reducing well spacing from 10 to 5 acres.

Exploratory activity in the Coastal region will also be featured by drilling associated with Shell Oil Co.'s discovery at Saticoy last year and the continued search for Sespe production in the Oxnard plains of Santa Clara Valley.

At Saticoy Shell found production in the Pico formation, Pliocene age, in an area thought to be associated with South Mountain-Oakridge field.

It's in the Oxnard plains where most geologists expect the major onshore exploratory action in California will take place in 1956. Object of this activity will be Sespe formation pay zones, three of which are producing in the Oxnard field 2½ miles west of the town of Oxnard.

The current development being the most closely watched in this region is Richfield's first wildcat being drilled in the town of Oxnard. This test, like those in the Montalvo and West Montalvo areas to the west of town, is aimed at Sespe production. The Sespe is found in the plains at depths ranging between 5,500 ft. and 11,000 ft.

Standard Oil Co.'s deep exploratory drilling program at Fillmore will continue in 1956. Standard has been carrying on the exploration and development of Fillmore field for more than 10 years. Except for four wells drilled close together in the field, Standard has been unsuccessful in efforts to extend production in any direction except for one producer completed a mile northeast of the discovery area. Most wells Standard drilled here are in the 15,000-ft. class. Standard spent close to $3,000,000 before getting the first successful completion in this field.

Los Angeles Basin . . . The big development in exploratory drilling in the Los Angeles Basin has been the growing public acceptance of slant-hole drilling from soundproofed, landscaped sites. As this type of operation is perfected, and, if the operators can sell residential property owners on its virtues, the Los Angeles Basin could become the scene of a big boost in exploratory drilling operations.

Typical of this type of work are the development of Universal Consolidated Oil Co. on the 20th Century movie lot in Beverly Hills and Richfield's Boyle Heights operations. In both cases, major discoveries were made in highly built-up residential and industrial districts where drilling was permitted only after elaborate soundproofing safeguards were set up.

Signal Oil & Gas Co. has announced intentions to begin a similar program on property offsetting Universal's movie lot operations. In this type of drilling, multiple holes are slant-drilled from a single site.

The recent discovery by General Petroleum of Santa Fe pool in old Santa Fe Springs field east of Los Angeles, has also touched off an exploratory flurry.

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How to Increase Your Drilling Rates

This is a discussion of recognized operating techniques, materials, and equipment which affect drilling rate. Considered application of these factors can help improve your rig performance.

by W. R. Wardroup and George E. Cannon

AVERAGE footage per rig year in the United States in 1950 amounted to 35,369 ft. and increased to 45,200 ft. in 1954. The drilling industry should be commended on this remarkable improvement which has been accomplished with no revolutionary changes in the method of operation.

However, this improvement has not resulted in reduced well cost nor reduced footage cost. The upward trend in well cost could be halted or reversed if more careful consideration is given to some of the more basic factors which affect the rate of drilling. Some of the ways to increase drilling rate are:

Authors are with Humble Oil & Refining Co. in Midland and Houston, respectively. Paper presented at 1956 Spring meeting of the Southwestern District, A.P.I., Division of Production, Fort Worth, under the title: "Some Factors Contributing to Increased Drilling Rate."

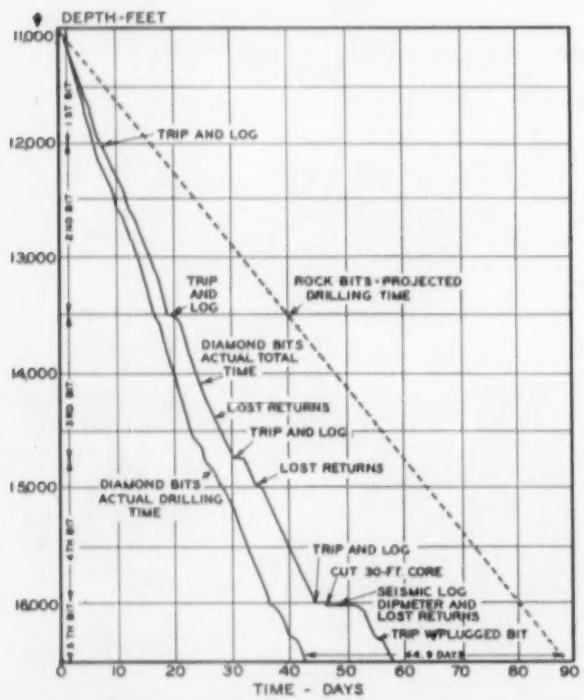
1. Use of bigger drill collars and more weight on the bit.
2. Selected application of "special" bits, i.e., drag bits for some soft formations, chert bits for hard formations, and diamond bits for medium-hard formations.
3. Maintenance of low mud density where possible.
4. Circulation of air, gas, or aerated mud.
5. Addition of surfactants to drilling water.
6. Use of larger mud pumps and increase of bit power and nozzle velocity.
7. Installation of feed control and use of equipment to speed up trip time and decrease down time.

Bits and drill collars . . . Improvements in bit designs and materials have contributed considerably to the increased drilling rate during the past few years. The use of large drill collars and stabilizers to minimize the rate of hole deviation has allowed more weight to be applied to the bit. In many areas, it is standard practice to use 6-in. drill collars in a 6¾-in. hole, 7-in. drill collars in a 7⅞-in. hole, and 8-in. drill collars in an 8¾-in hole.

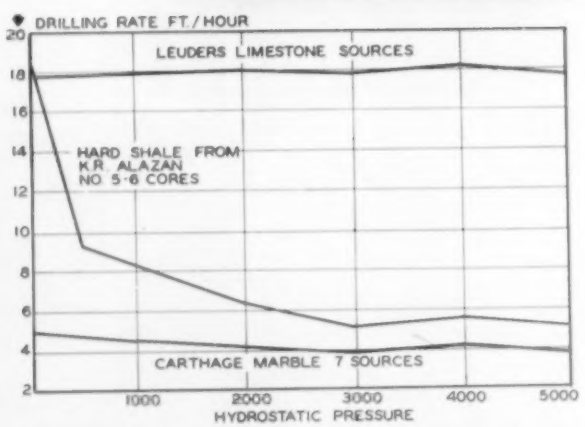
The use of increased numbers of drill collars has been possible through improved drill-collar joint design and drill-collar maintenance. Performing routine field inspections has minimized the number of fishing jobs for drill collars. Bit weights amounting to 10,000 lb. per inch of bit diameter are not uncommon in the harder formations.

The type of bit used is also very important. It is unfortunate that the drag-type bit is passing out of the picture as there are numerous formations and areas where other type bits have not been able to compete with it.

Judicious use of so-called special bits has contributed to the improvement in drilling rate during recent years. One of the special bits is the chert bit. Although it is not a cure-all for hard-rock drilling, its use has gained in popularity and has resulted in considerable saving in rig time and cost in many wells. Table 1 shows what is probably an extreme example of the savings that can be made with the chert-type bit. In drilling a chert section of 106 ft. a total of 20 conventional bits was required in one well as compared to one chert-type bit in an offset well. Cost per foot was reduced from $143 to $25 in the well using the chert bit.



DIAMOND BITS saved 45 rig-days on this well. The saving was mostly due to a higher percentage of rotating time on bottom. This was 85 per cent compared to the 40 to 45 per cent that was delivered by rock bits. Fig. 1.



HYDROSTATIC PRESSURE on the bottom of the hole decreases drilling rate for some formations while others are not affected. This effect has made attractive the use of aerated muds and air and gas to decrease pressure. Fig. 2.

Diamond bit . . . Another type of special bit which is gaining in poularity is the diamond drilling bit. The diamond drilling bit has proved most successful in the smaller sizes, i.e., 7-in. o.d., or less. There is a great deal to be learned about the type of formations in which diamond drill bits can be most successfully employed. Unusual as it might seem, there is some property other than formation hardness which appears to be the controlling factor in considering the use of diamond drill bits.

Fig. 1 shows the drilling rate obtained with diamond drilling bits in Armstrong field, Kenedy County, Texas. Four 6⅜-in. diamond drill bits were used in drilling medium-hard Frio and Vicksburg formations from 11,000 to 16,000 ft. The fifth bit used from 16,000 to 16,497 ft., was left in the hole. Each of the first four bits was pulled only because well logs were desired and not because the bits were dull.

Estimated penetration rate with conventional rock bits is based on experience in the area. It is seen that 45 rig-days were saved by using diamond bits. The time saving in large part is the result of the high percentage time rotating on bottom, which was 86 per cent as compared to 40 to 45 per cent with conventional bits. An 18-lb. per gal. mud was used in this well. Reduction in trips undoubtedly saved thousands of dollars in mud cost by eliminating pressure surges and gas cutting caused by making trips to change bits.

Equally as good results have been obtained on other wells in the South Texas area in drilling Frio and Vicksburg formations. However, diamond bits have not been successful in drilling the Travis Peak formation in South Texas. Likewise, the use of diamond drill bits in the Pennsylvanian and Mississippian formations in West Texas and New Mexico has been generally unsatisfactory.

TABLE 1—COMPARISON OF CHERT-TYPE AND CONVENTIONAL ROCK BITS—YARBROUGH AND ALLEN FIELD, ECTOR COUNTY, TEXAS

	Interval drilled (ft.)	No. of bits	Total hours	Feet per hour	Cost per foot
Conventional	8,233 to 8,339	*20	74¼	1.4	$143
Chert type	8,230 to 8,336	1	26	4.1	25

*Seventeen reamers.

Mud weight . . . There has been much discussion about the effect of mud density in reducing drilling rate. Field and laboratory experiments indicate that density change alone is not the controlling factor and that other properties which accompany density changes and are not now measured will have to be investigated.

Table 2 shows the results of a series of tests conducted in Andrews County, Texas. Mud density was varied from 8.9 to 11.2 lb. per gal. During the tests, bit weight, rotary speed, and circulating rate were maintained constant. Only small batches, i.e., 75 bbl. of each weight mud, were used and the drilling rate was accurately recorded as the mud was discharged from the bit.

Assuming the drilling rate with water to be 100 per cent, the data in Table 2 show the relative drilling rate to be reduced to 57 per cent as the drilling mud weight was increased to 11.2 lb. per gal. In these tests, the volume of mud was such that the change in the hydrostatic pressure on the formation was insignificant.

TABLE 2—EFFECT OF VARIATION IN MUD DENSITY ON DRILLING RATE

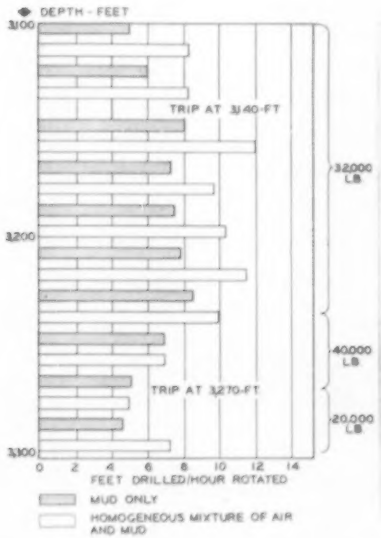
(B-2 Georgia B. King, Means district, Andrews County, Texas)

Hole size—8¾ in.
Bit weight—68,000 lb.
Circulation rate—625 g.p.m.
Formation—San Andres dolomite.
Depth—4,800 to 5,400 ft.

Mud weight (lb. per gal.)	Relative drilling rate (per cent)
Water	100
8.9	82
9.23	78
9.6	72
9.6	76
10.1	73
10.5	62
11.2	57

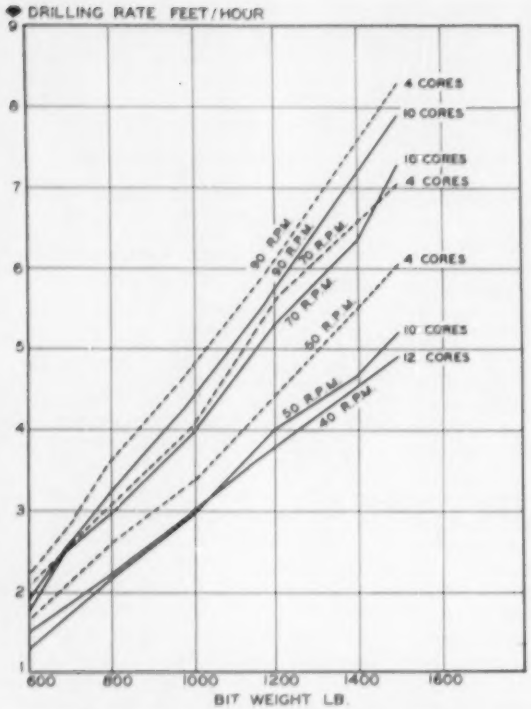
In some formations, increasing the hydrostatic pressure may reduce drilling rate. However, these pressure effects will vary with the permeability and perhaps other properties of the formation. Fig. 2 shows the results obtained in the laboratory with three different types of formations. The very permeable Lueders limestone was not affected by increasing the pressure. However, there was considerable reduction in the drilling rate as the pressure was increased on less permeable Frio shale and Carthage marble.

Circulating air and gas . . . During the past 2 years there have been numerous

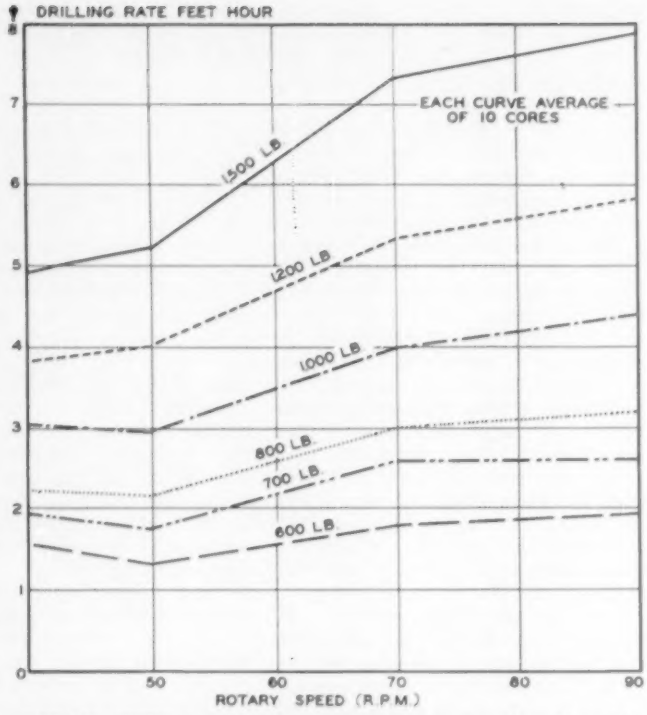


AERATED MUD increased drilling rate 23.6 per cent in alternate drilling intervals in this well. Fig. 3.

SURFACTANTS in water used for drilling have yielded drilling rates higher than rates for untreated water. These laboratory bits show that the better cleaning action of the treated water (bit at right) may be responsible. Fig. 4.



EFFECT OF BIT WEIGHT is to increase drilling rate proportionately. Data are result of laboratory drilling with miniature bits. Fig. 5.



ROTARY SPEED has less effect on drilling rate than does bit weight. Field tests have confirmed that increasing bit weight is about twice as effective. Fig. 6.

articles written on air and gas drilling. It is unfortunate there are so few areas where this method of drilling can be used because of formation waters. There is much-needed research to be done on the problem of shutting off formation waters in order that the air or gas method of drilling may be extended.

In Humble's operations, air or gas drilling has been used successfully in North Texas, West Texas, Southwest Texas, and New Mexico. The most outstanding results Humble has obtained using gas drilling is in Val Verde County, Southwest Texas, the results of which are given in Table 3. This table shows that in drilling comparable formations from approximately 1,500 to 9,500 ft. the use of gas instead of mud as the circulating fluid saved 40.6 rotating days and 107 rock bits. The wells compared are located about 3 miles apart.

In some areas it is impossible to use air or gas as the drilling fluid because of formation water or it may be undesirable to do so because of other reasons. In such cases, aerated mud or water may be used to increase drilling rate over that obtained by use of mud or water. Humble has had very little experience with aerated-mud drilling. However, controlled tests in one well have shown that improvements in drilling rate can be obtained.

Fig. 3 shows the data obtained in Lea County, New Mexico, when alternate 10-ft. sections were drilled using mud and air-mud mixture. Because approximately 20 minutes was required for a complete circulation cycle, only the last 5 ft. of each 10-ft. interval drilled was considered for this comparison. An increase in penetration rate

TABLE 3—COMPARISON OF GAS VS. MUD DRILLING—VINEGARONE FIELD, VAL VERDE COUNTY, TEXAS

Total days	Interval (ft.)	Footage drilled	Hours rotated	Feet drilled per hour rotated	Footage per bit	No. of bits used
	Well No. 1—Gas Operations					
22	1,581 to 9,500	7,919	224.25	35.3	377	21
14	5,920 to 9,500	3,580	113.5	31.5	256	14
	Well No. 2—Mud Operations					
80	1,500 to 9,504	8,004	1,198.0	6.7	62	128
	Well No. 3—Mud Operations					
57	5,999 to 9,488	3,489	854.25	4.1	47	74

TABLE 4—EFFECT OF SURFACTANT MATERIALS ON BIT PERFORMANCE

	Drilling fluid	Interval (ft.) From	Interval (ft.) To	Footage	No. bits required	Feet per bit	Rotating time (hours)	Footage per hour
	1. Hutex Devonian Field, Andrews County, Texas							
7 wells	Water	5,182	6,552	1,370	6.4	214	66.14	20.71
1 well	Surfactant*	5,108	6,493	1,385	4	346	58.00	23.88
Average:								
7 wells	Water	6,552	7,689	1,137	5	227	56.43	20.15
1 well	Surfactant†	6,493	7,611	1,118	5	224	60.00	18.63
	2. Dean Devonian Area, Lea County, New Mexico							
Average:								
5 wells	Water	4,963	9,760	4,827	57.6	83.8	462.75	10.43
1 well	Surfactant†	4,750	9,590	4,840	42	115.2	382.75	12.65

*Anionic type. †Nonionic type.

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of 23.6 per cent was realized over the entire test section of hard limestone when an air-mud mixture was used instead of mud.

Surfactants . . . We are all familiar with the increased penetration rates that can be obtained by using water in place of mud whenever possible, using a low-solid-content drilling mud and using oil emulsions in either mud or water. Generally, improvements in drilling rate and bit life are noted regardless of the type of bit being used or the formation penetrated. Until recently it was assumed that the ultimate had been achieved as far as liquids were concerned when clear water was used as the circulating medium.

However, tests by several opeartors have shown that the performance of rock bits can be improved by the use of surfactant materials in the water. The mechanism by which bit performance is improved by the use of surfactant materials is not clearly understood, and a large amount of research work remains to be done on this problem.

Some idea of what might be happening is illustrated by Fig. 4, which is a picture of a laboratory bit used to drill hard shale. The balled-up bit shown on the left was used with fresh water, and the clean bit shown on the right was used in conjunction with a surfactant material in the water.

Table 4 shows field data obtained using two types of surfactant materials, i.e., the anionic or negative-charged particle and the nonionic or neutral particle. In the first tests in Hutex Devonian field, the use of the anionic surfactant improved bit life—214 ft. per bit to 346 ft. per bit; increased penetration rate—20.71 ft. per hour to 23.88 ft. per hour; and reduced number of bits from 6.4 to 4 required to drill the 1,385 ft. of test section. The test was continued using a nonionic material and no improvement in bit performance was observed.

However, in another series of tests in the Dean Devonian area of Lea County, New Mexico, using the nonionic surfactant, the number of bits required to drill a 4,800-ft. section was reduced; footage per bit was increased; and drilling rate was increased. The use of surfactant materials offers a most promising approach to increasing drilling rate where liquids are used and may also have application in air or gas drilling.

Hydraulics . . . The hydraulic system continues to be the key to success of the rotary system of drilling. A large amount of work remains to be done in evaluating the larger-size mud pumps which have become available during the past few years.

In drilling of the softer formations, the design of the hydraulic system is very important. However, the hydraulic system becomes of secondary importance as the formations become harder and the ability to generate cuttings decreases.

In a series of tests conducted in the 2 Georgia B. King, Deep Rock field, Andrews County, Texas, a uniform lime section was selected for test purpose from 6,790 to 8,220 ft. The bit size used was 8¾-in. and a bit weight of 60,000 lb. was used. Alternate intervals of from 5 to 45 ft. were drilled using a 650 and a 925-hp. pump. The horsepower developed by the smaller pump averaged about 350 and by the larger pump about 600. The average drilling rate using 350 hp. was 19.56 ft. per hour as compared to 19.3 ft. per hour using 650 hp.

As formations become softer, however, horsepower plays an important part in rate drilling. As an example, in Borregos field in Southwest Texas, the rate of penetration was increased from an over-all average of 28.7 ft. per hour to 114 ft. per hour by increasing the hydraulic horsepower input from 200 to 800.

. . . Bit weight and rotary speed play a very important part in drilling rate.

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Unfortunately, we are unable to take full advantage of both of these factors, and in actual operations there is always a compromise because of bit cost and the cost of making round trips. The large improvement in drilling rate cited in the opening paragraph is the result in part not only to bit improvements but also to a better understanding of the mechanism of obtaining the maximum footage from a bit at the fastest economical rate.

The effect of bit weight and rotary speed on drilling rate has been investigated in Humble's drilling research laboratory. In this laboratory, miniature bits are used to drill small samples, and formation conditions of temperature and pressure can be duplicated. Typical of the type of data which can be obtained is shown by Figs. 5 and 6, which show the effect of bit weight and rotary speed, respectively, on the drilling rate obtained in Carthage marble.

The proportionate increases in drilling rate obtained by increasing bit weight or rotary speed within the limits of the test are of the same magnitude as has been observed in actual field tests. Increasing bit weight is approximately twice as effective in increasing drilling rate as is increasing the rotary speed if either is increased by the same percentage.

Auxiliary equipment . . . In addition to the factors directly affecting the rate of penetration there are several items of auxiliary equipment which will affect the rate of drilling either in increased penetration rates or decreased trip time. Several types of feed controls are available which have been found to be satisfactory. A comparison of penetration rates on 7 wells before and 10 wells after the installation of a feed control on a Humble rig in West Texas showed a 10.6 per cent increase in penetration rate on those wells drilled with the feed control.

Air hoists in the derrick have been found to be a safe and efficient method for handling long strings of drill collars as well as reducing trip time. Also, the use of air hoists on the floor has proved to be a more efficient and safer method for handling drill pipe and casing than the cathead.

An item which is difficult to justify on a rig drilling shallow wells is power slips. However, on deep wells the use of power slips will reduce crew fatigue which will contribute to decreased trip time.

Hydraulic couplings, torque converters, air brakes, adjustable stabbing boards, and power tongs also contribute indirectly to increased drilling rates because of decreased fatigue of personnel and decreased rig down time for repair.

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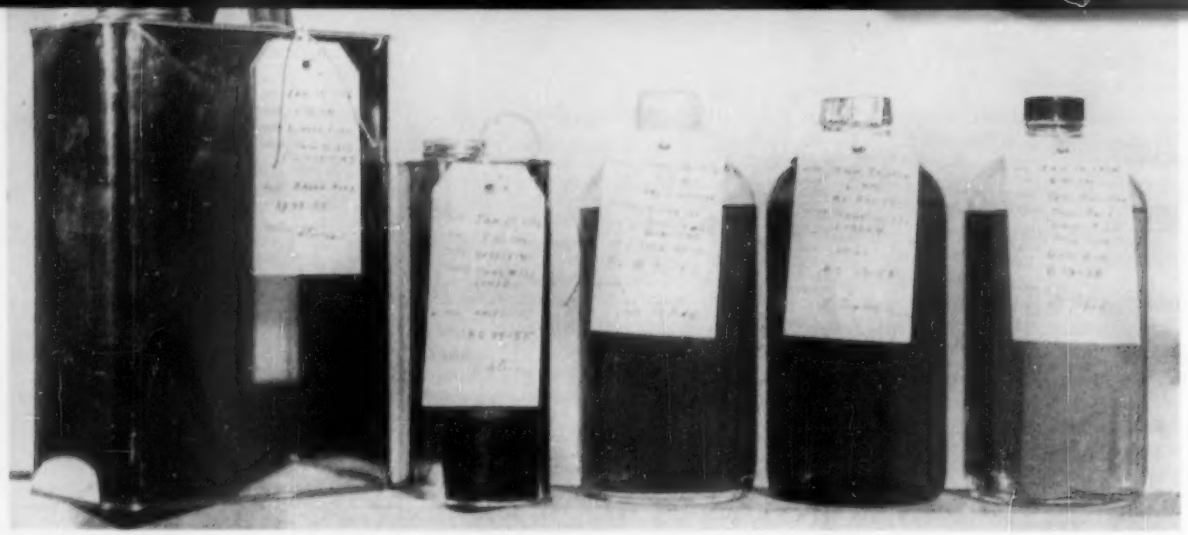


APPROVED SAMPLE CONTAINERS for bunker fuel, kerosine, and gasoline. Fig. 1.

CONTINUOUS AUTOMATIC SAMPLING—4

Care and Handling of Samples

The previous articles in this series[1 2 3] have outlined the problems encountered in sampling, and the methods and equipment which might be used to obtain representative samples. This paper covers the treatment of the sample from the time it is drawn from the pipeline, storage tank, or unit until it is delivered to the laboratory for test. Precautions or procedures for withdrawing test portions from the sample container are not covered. These, where special handling is required, are outlined in the applicable A.S.T.M. test method.

by J. H. Berglund

SAMPLING is an extremely important function in the petroleum business. The sample is the main tool by means of which the quality (and of course the price) of a product is established before a purchase or sale. Test results determined by the best analyst are worthless if the sample is not absolutely representative of the bulk of material in the lot or shipment.

Therefore, as soon as the sample is obtained, extreme care must be exercised to insure delivery to the laboratory without contamination or deterioration of the sample. A prime precaution, of course, is that the sample container must be absolutely clean and free of any dirt, lint, moisture, washing compounds, or other foreign materials which might contaminate the sample. It should be washed and dried thoroughly, using a cleaning procedure such as is outlined in the A.S.T.M. Method of Sampling Petroleum and Petroleum Products (A.S.T.M. Designation D-270).*

Author is with Esso Research & Engineering Co., Linden, N. J. He was assisted by W. V. Cropper, Standard Oil Co. (Ind.), Chicago.

Sample container . . . In some cases the sample may be collected in a container which is an integral part of the automatic sampling assembly. Such a container may not be suitable for shipping or transporting the sample to the laboratory. It may be necessary to transfer the sample to a clean dry bottle or can (Fig. 1).

The transfer must be made in such a manner that the composition of the material will not be altered. For example, in the case of a highly volatile material, care must be taken that no light ends are lost. Obviously, the loss of light ends would seriously change the distillation range and vapor pressure of the sample. It may be necessary to chill the sample in some cases.

If the quality of the sample is not affected by contact with water, transfer may be made by water displacement. Siphoning may be satisfactory for some products and, of course, simple pouring will not affect most nonvolatile materials. When handling a liquid-gas mixture such as a crude oil containing small amounts of propane, ethane or hydrogen sulfide, means must be provided to preserve the original pressure conditions. Liquid displacement using pressurized brine is used in some cases where the brine will not affect the material.

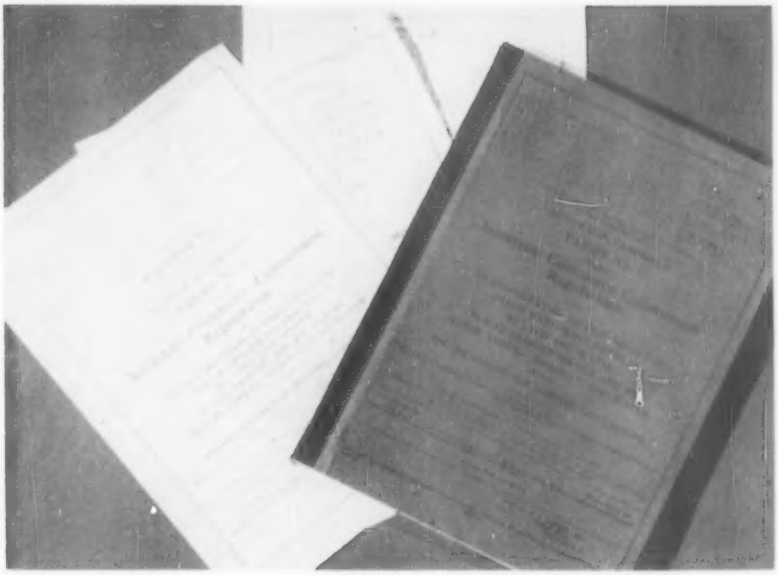
Nonhomogeneous materials such as waxy crudes or mixtures of oil and sand or other immiscible materials require special treatment to insure that all of the contents are transferred to the sample container. Vigorous agitation usually will reduce loss by separation.

In any case, the operator must exercise good judgment, based on the type of testing to be done as well as the nature of the material. Special precautions to be followed when obtaining samples to be used for certain specific tests also are outlined in the A.S.T.M. Method of Sampling (D-270).

Volatile sample . . . In the case of a sample having a Reid vapor pressure of more than 16 lb., the container must be strong enough to withstand the pressure of the material with a safe margin. Usually local safety regulations state definite specifications for pressure containers to be used for various classes of materials. Containers should comply with these regulations.

*A.S.T.M. designation D-270 appears in 1955 Book of A.S.T.M. Standards, Part 5.

REFINING



INTERSTATE COMMERCE COMMISSION REGULATIONS must be followed if sample is to be shipped by a common carrier. Fig. 2.

If the sample is to be shipped via a common carrier, the requirements of the Interstate Commerce Commission, as outlined in Agent H. A. Campbell's Tariff No. 9,† must be complied with Fig. 2. It is important also that a sufficient outage be provided in the container to allow for expansion. Never attempt to ship a completely full container.

Certain materials, such as leaded gasolines, are sensitive to light and should be protected by using brown-glass bottles or by covering clear-glass bottles with paper or cardboard. Properties such as color, tetraethyl lead and inhibitor contents, oxidation stability, and sludge-forming characteristics may change after prolonged exposure to light. Tests on an exposed sample, therefore, may not be representative of the bulk of material.

The container must be stoppered immediately after the sample is obtained or transferred. It is advisable also to cover the stopper with a cap of paper, plastic, or metal foil. This reduces the possibility of loss of liquid or vapors. Paper-capped bottles can be sealed for shipment or stoppage by dipping into paraffin wax or other suitable material so that all of the cap and part of the neck of the container are covered. Paraffin or sealing wax should never be poured directly over stoppers (Fig. 3).

Identification . . . Another very important requirement for the proper care and handling of samples, is a clear and positive identification. Each sample must be identified with a tag label, tied securely to the neck or handle of the container (Fig. 4).

All pertinent information must be marked on the label such as the date; time; sampler's name; number or name of the vessel, car, tank, pipeline or other container from which the sample was drawn; brand and grade of material; and identification number.

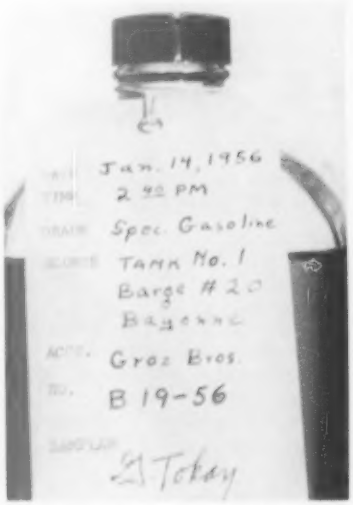
The A.S.T.M. Method of Sampling specifies that "waterproof and oilproof ink should be used, or a pencil hard enough to dent the tag, since ordinary ink markings are subject to obliteration from moisture, oil smearing, and handling."

In many large plants, samples are obtained periodically and then placed at central locations where they are picked up for delivery to the laboratory. Means should be provided at such locations to protect the samples from heat and light since several hours may elapse before the actual pickup takes place.

Never allow the samples to stand in direct sunlight, and, of course, volatile samples must be kept cool. The pickup location should be provided with a shaded rack or cabinet. A cold box or cold water tray (ice cooled if necessary) should be installed for storing samples (Fig. 5). The same provisions

†Tariff No. 9 publishing Interstate Commerce Commission Regulations for "Transportation of Explosives and Other Dangerous Articles by Land and Water in Rail Freight Service and by Motor Vehicle (Highway) and Water Including Specifications for Shipping Containers." Issued by H. A. Campbell, agent, 30 Vesey Street, New York 7.

SUITABLE CLOSURES AND SEALS for sample containers. Fig. 3.



POSITIVE IDENTIFICATION is a must for samples. Fig. 4.

A COLD BOX or cold-water tray should be installed for storing samples. Fig. 5.

should be made at the laboratory for storing the samples until the tests are taken.

Retaining samples . . . Often in cases of custody transfer and contract sales, samples must be retained for a stipulated time after initial testing has been completed. In selecting storage facilities, consideration should be given to conditions of safety, temperature, light exposure, detection of leakage, and precautions against corrosion of the sample containers. Storage areas should be inspected frequently to detect leaks and breakage.

Conclusion

The problems and conditions outlined here should be sufficient to stress the importance of the duties of sampling personnel. All too frequently, sampling duties are assigned to unstrained and unskilled employes who may not even be under the direct supervision of the laboratory organization. It is imperative that the handling of samples in all its phases—obtaining transfer, transportation, storage—should be carried by competent, conscientious, and well-trained personnel.

The precautions for the care and handling of samples may be condensed to the simple rule of "USE GOOD COMMON SENSE," so that:

1. The sample will be truly representative of the bulk of material in the lot or shipment.
2. Deterioration or contamination of the sample will be avoided.
3. The sample will be positively identified.

I.P. Sampling Panel Comments on Automatic Sampling Symposium

by D. A. Yonge

IT is evident that much careful thought has been devoted by the A.S.T.M. to the problem of automatic sampling and that much progress has already been made in the development of mechanical sampling devices. Although the advantages of a reliable automatic sampler are undeniable, it is felt that the application of such devices in the oil industry in the United Kingdom would be limited.

In all four papers the authors have concerned themselves almost entirely with the problem of samples from pipelines and have concentrated on crude oil containing water and sediment. American interest in this direction is undoubtedly stimulated by the country's system of large pipelines for transfer of oil over long distances and for long periods, but such a system has no counterpart in the United Kingdom, where crude oil is delivered directly to the refinery by ocean-going tankers.

Under these conditions only samples taken from the ships' tanks themselves would really be acceptable to all parties in the event of a dispute. With modern rates of pumping a cargo will be discharged so quickly that samples could be obtained manually from the receiving shore tank after discharge almost as soon as an automatic pipeline sample could be secured, the latter having to cover the whole period of discharge.

The refinery itself is, of course, interested in the condition of the oil in the shore tank from which the plant will be fed and the only extent to which automatic sampling has been attempted in connection with crude-oil supplies is in the development of a probe for insertion in the feed line between storage tank and plant with the object of warning the latter of the approach of any slugs of water.

Refinery Sampling

For the control of refinery processes the operator is interested in following changes in plant streams at short intervals in order to correlate plant conditions with the quality of the product. For this purpose spot samples or at least representative samples covering only short periods of time are required, and the mechanical sampler would have to be capable of providing these. The Nelson device,[2] which collects in 6-96-hour periods would obviously be quite unsuitable for this purpose.

Similar remarks apply in the case, for example, of a tanker discharging two dissimilar products simultaneously, when the detection of contamination of one of the other at an early stage in the discharge is necessary to avoid making a major quantity of product unmarketable. Mechanical samplers which collect a representative sample over a long period serve no useful purpose here and the device must be capable of obtaining a representative sample over very short periods of time, preferably for use with an automatic testing instrument.

There would, therefore, be great possibilities in connection with plant control in the use of mechanical sampling in conjunction with continuous automatic analyzers giving a recorded picture of variations in quality in the line. There is no little interest in United Kingdom refineries in such devices and some development work has already been done on instruments with this ob-

D. A. Yonge is with Shell Refining & Marketing Co., Ltd., London. He is chairman of Subcommittee 1, sampling panel of Institute of Petroleum.

ject, for example, for recovering specific gravity, viscosity, flash point, and vapor pressure.

The main difficulty, however, in the use of automatic sampling in complicated pipeline systems through which plant streams may be transferred to any one of several tanks is that to detect line contamination from leaking valves, the sampler must be situated as near as possible to the receiving tank. This would involve the installation of a great many samplers, which, with their associated instruments, would be relatively expensive, while a single sampler in the line near the plant in a situation in which it would serve all the tanks would not detect line contamination from this cause.

Finished products . . . For finished products it is doubtful whether automatic sampling would have much application in the United Kingdom for many years to come, as the accepted basis for sale is the quality of the product delivered. This involves drawing samples from tank wagons, etc., since a mechanically obtained sample from the delivery line to the tank wagon will take no account of contamination which may occur in the vehicle tank itself.

The avoidance of such contamination is usually the responsibility of the supplier and the only guarantee is a sample taken from the loaded vehicle. None of the papers indicates any development of mechanical devices for sampling storage tanks or tank cars and manual sampling with its admitted weaknesses remains the only method.

On the question of the deficiencies of manual sampling the statement[3] that "quality and quantity determinations based on tests of samples secured manually is at best accurate only to 0.5 per cent and could be inaccurate to as high as 1.0 per cent or more" is open to dispute as regards the accuracy of manual sampling. While the over-all errors may be of this order, the major part is contributed by recognized inaccuracies in the test methods themselves (which would still occur with automatic sampling) and this statement is, therefore, felt to give an unfair impression of manual sampling.

Moreover, while the accuracy tolerance of positive displacement meters must be within 0.10 per cent, it is doubtful whether this can be maintained in practice. Incidentally, reference[1] is made to sampling of drums, tank cars, tankers, and large storage tanks by "all levels" sampling and the "running bottle thief."

Owing to the difficulty in insuring that an all levels or running bottle sample is, in fact, what it is intended to be (i.e., containing equal proportions of oil at all levels throughout the tank) the Institute of Petroleum no longer recommends this method for the large tanks and is considering deletion of all reference to it from method I.P. 51.

Labor saving . . . On the question of labor saving, while there can be no doubt that mechanical samplers must reduce the need for employment of manual sample dippers, it has to be borne in mind that the mechanical device, for its efficient operation, demands meticulous care in maintenance and that the labor requirement for this purpose will probably outweigh any economy in manpower for sampling at least until a completely foolproof and trouble-free device can be evolved.

On the question of the practical application of these devices, the weakest link would appear to be the purging of the sampling system. No indication is given of the absolute success of any of these systems. The question might therefore be asked: "How does the operator know that purging has been completed without any possible chance of the next sample being affected by a small quantity of the previous product being retained in the valve, caps and in many blind points which are most difficult to clear?"

These comments are not to imply any lack of interest in the United Kingdom in the matter. The value of automatic devices of this nature is not underrated, but it is felt that the A.S.T.M. is endeavoring to cater for different conditions from those encountered here. Nonetheless, the progress and development of automatic and mechanical sampling in the States will be followed with interest.

Theory of Continuous Sampling

The approach to this subject[1] seems to us somewhat confusing. The definition of "a homogeneous liquid" as merely one where "evetrything in the flowing stream is in the liquid phase and completely miscible" is hardly appropriate in sampling for analytical purposes. The changing properties of the liquid are the whole reason for sampling and "homogeneous" should more logically mean "uniform in properties."

We contend that this is the more usual meaning in this field and that the authors' use of homogeneous includes the case which would normally be called heterogeneous. In the discussion of a streamline homogeneous liquid flow (based on Fig. IV[1]), the authors appear to be using the more usual meaning of homogeneous (otherwise it is hard to see why they differentiate between this and the heterogeneous case).

If a liquid is really homogeneous with respect to the property being measured there is no sampling problem—the liquid is homogeneous for the whole cross-section of the pipeline and along its length. In the case of a single-phase liquid whose property of interest varies along the pipe line, under conditions of streamline flow, the central core moves faster than the liquid near the pipeline wall so that mixing occurs and there is not true homogeneity over a cross-section.

The case of streamline flow of a single phase liquid should therefore be treated as one of a heterogeneous liquid and sampled accordingly. It is not clear why "theoretically, the best sample could be obtained by a probe entering the pipe about ¼-in. diameter."

Heterogeneous liquid . . . Turning to the case of the streamline flow of a heterogeneous liquid there are at least two important probable distributions of the property of interest in a pipeline, with the likelihood in practice of combinations of these. These are where gravity is effective in imposing a variation in quality in the vertical direction only, and where gravity is not effective and a distribution of radial symmetry is present. To obtain a representative sample by means of a shaped slot would require quite different shapes in each instance.

In practice these idealized distributions are unlikely to be found alone and experiments with streamline flows and colored liquids suggest how easy it could be for a single "streamer" of a contaminating liquid to avoid completely any kind of probe, and yet contribute substantially in the bulk of material transferred.

It is considered that streamline flow presents great difficulties in obtaining a representative sample and that an answer of universal application is not possible. In practice the case is rarely met and in the few cases where it might be of extreme importance to get a representative sample from a streamline flow the best solution would be to change this flow to turbulent by narrowing the pipe for a section.

In principle the probe proposed for the heterogeneous turbulent case is sound. There is some experience however in measuring the water content of crude oil with a slotted probe that fouling by fibrous solid material soon completely blocked the slot.

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A New Way to Analyze Hyperperoxides in Gasoline

by Charles W. Ripple

HYPERPEROXIDES are formed when hydrocarbons and oxygen react in the presence of air, cause gum formation, and reduce octane number of the base gasoline.

The hyperperoxide is detrimental to gasoline because of the deposits in the manifold of the automotive engine. Hyperperoxides can materially increase the over-all treating costs since the efficiency of tetraethyl lead is materially reduced in the base gasoline.[1]

The most recent analysis of hyperperoxides in petroleum products[2] used sodium arsenate solution to reduce peroxides in an alkaline media. This excellent paper reported that occasional samples of gasoline gave negative hyperperoxide numbers indicating the presence of reducing agents in the gasoline.

Recently, Texaco[3] extracted the phenylenediamine inhibitor with tenth normal hydrochloric acid to determine the amount of inhibitor present in the gasoline.

Medalia[4] reported chain reactions which caused low results using the well-known ferrous sulfate procedure.[5]

Procedure revision . . . We have revised the Walker & Conway procedure as follows:

1. 110 milliliters of gasoline are extracted twice with 50 ml. of tenth normal hydrochloric acid for 1 minute, then are water-washed and decanted.

2. Add 5 ml. of tenth normal sodium arsenate solution, 10 ml. of 10 per cent NaCl, 2 g. of $NaHCO_3$, 20 ml. of ethyl alcohol, 20 ml. of distilled water, and 100 ml. of the above acid-extracted gasoline.

3. Reflux for 30 minutes using a condenser equipped with a ground-glass connection.

4. Cool, separate the gasoline from the aqueous layer in a separatory funnel, wash twice with 20-ml. distilled water, then cool to 20° F. in a 250-ml. glass-stoppered flask.

Author is with Electric Process Co., Summit, N. J.

5. Add 1 g. of sodium bicarbonate and titrate with standard 0.05 normal iodine using a starch indicator.

6. Run a blank determination without gasoline using the same amounts of reagents and the same procedure.

Calculation . . . The hyperperoxide number is expressed as milliequivalents of active oxygen per liter as follows:

$$HpN = \frac{1{,}000\ N \times (B - S)}{V}$$

"B" is the milliliters of iodine solution used in the blank.

"S" is the milliliters of iodine used for the sample.

"N" is the normalty of iodine solution.

"V" is the milliliters of the sample used.

Example: 100 ml. of inhibited sweetened gasoline extracted with tenth normal HCl required 12.7 ml. of iodine solution according to the above procedure. The blank determination required 14.0 ml. of iodine solution since the

$$HpN = \frac{1{,}000 \times 0.05 \times (14.0 - 12.7)}{100}$$

$$= 0.5 \times 1.3 = 0.65$$

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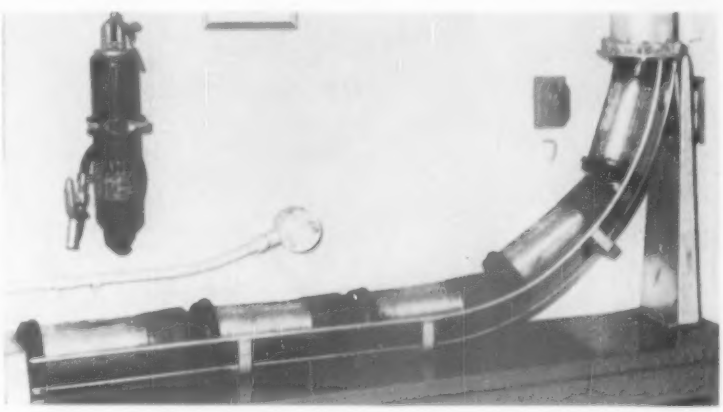

Union Oil Gives Refinery Samples a Free Ride

TAKING a tip from department stores, Union Oil Co. has installed this pneumatic conveyor system at its Oleum, Calif., refinery. The tube is used to transport quart sample bottles from its new marine terminal to the control laboratory some 2,800 ft. away. Previously the samples were hauled by truck. Usually a trip was not made until a dozen or more samples had been accumulated. Now the samples can be fired through the 6-in. aluminum tube at any time.

PIPELINES

ACROSS THE NATION...

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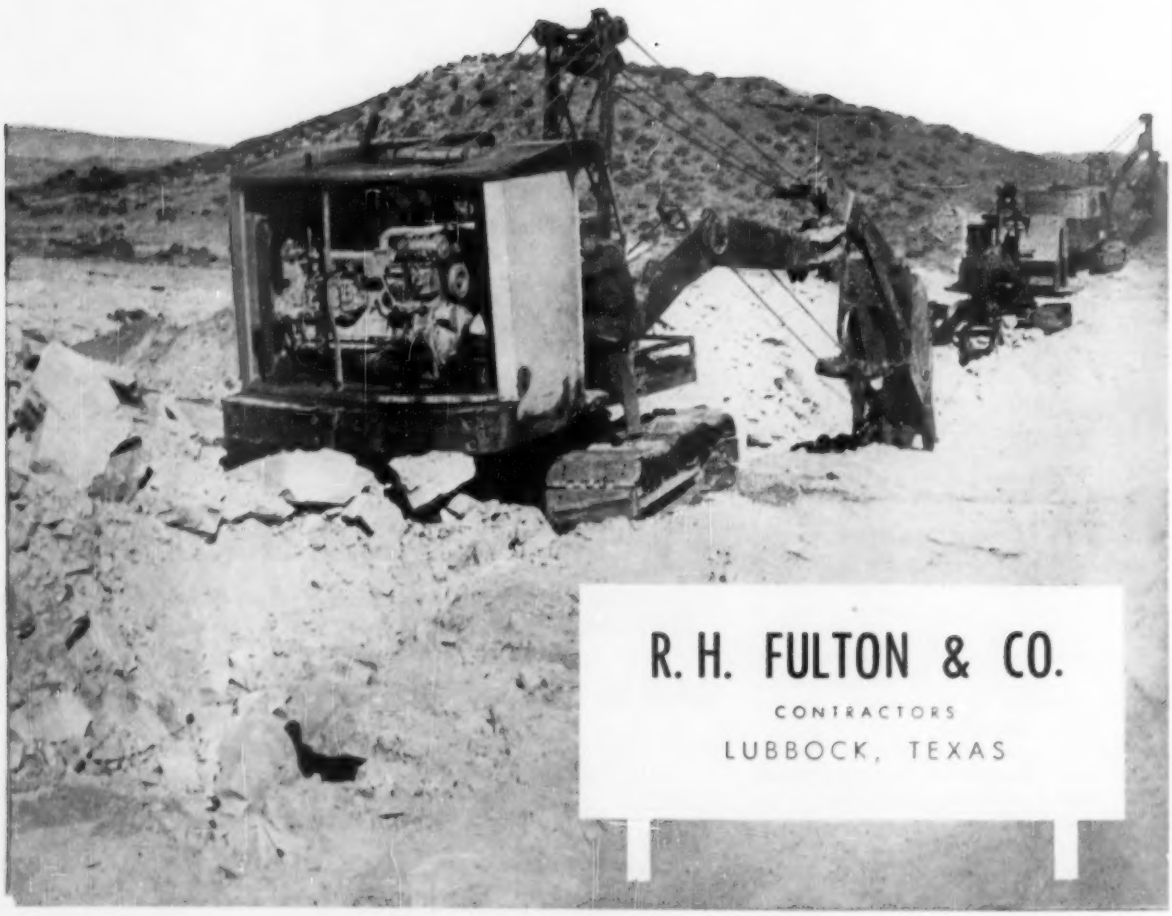
RIVER CROSSINGS
PRODUCTS PIPELINES
GAS PIPELINE CONSTRUCTION



Pipeline Patrol

. . . Report on Construction

PIPELINE activity reported here is compiled from surveys conducted by The Oil and Gas Journal among pipeline companies and contracting firms. Projects listed include those proposed, contracted, and under way. Uncontracted projects are indicated by ● preceding the project.

Crude-Oil Pipelines

Buckeye Pipe Line Co.—Will complete in October or November 1956, own reconditioning of 191 miles of 8-in. from Griffity, Ind., to Lima, Ohio.

Cities Service Oil Co. & Subsidiaries.—Rerouting of 6 miles of 8-in. north of and through Ponca City, Okla., to be completed by Roy L. Johnson, April 30, 1956.

Lakehead Pipe Line Co., Inc.—Let 51 miles of 26-in. looping in Minnesota and North Dakota, to Anderson Brothers Corp. Job to be completed summer of 1956, is in conjunction with 69 miles of 24 and 26-in. looping to be completed this summer by Interprovincial Pipe Line Co. (See Interprovincial, foreign crude.)

● **Magnolia Pipe Line Co.**—Plans 14 miles of 16-in. from Ringgold to Addington, Tex., to be completed June 1, 1956. Plans a 22-mile, 8-in. gathering system, plus 3 and 4-in. laterals in Nolan County, Texas, to be completed May 15, 1956. Plans 36 miles of 12-in. from Andrews to Midland, Tex., to be completed January 1, 1957.

● **Offshore Gathering Corp., Houston.**—Proposes a natural-gas and a crude-oil line, each about 364 miles, to gather gas and crude in Gulf of Mexico off Louisiana. Gas line to be 60 miles of 24-in., 70 miles of 26-in., 234 miles of 30-in. Crude line to be mostly 20-in.

● **Pasotex Pipe Line Co.**—Plans 127 miles of 20-in. along its route from Wink to El Paso, retiring another dual 8-in. section.

● **Shannon Oil Co., Denver.**—Plans with Farmers Union Central Exchange, Inc., and Mule Creek Oil Co., both of Billings, Mont., a 34-mile, 6-in. line from Murphy Dome in Hot Springs County, Wyoming, to contact Ohio Oil Co.'s line in Big Horn County. Construction to start in August, end by December 1, 1956.

● **Sinclair Pipe Line Co.**—Building a 300-mile line from Jacksboro, Tex., to Houston. River Construction Corp. has 152 miles of 18-in. from Jacksboro to Teague, Tex., to be completed April 25, 1956. Two spreads are working: H. C. Arthur, superintendent, office at Weatherford; E. L. Maggard, superintendent, office at Hillsboro. Remaining 150 miles of 20-in. not yet let.

● **Tecumseh Pipe Line System.**—190 miles of 20-in. will be built by Sinclair Refining Co., Pure Oil Co., Ashland Oil & Refining Co., between East Chicago and Cygnet, Ohio.

● **Union Oil Co. of California.**—Proposes 815-mile line from Rifle, Colo., to Los Angeles refining area, to carry products from its proposed Rifle shale-oil plant.

Products Pipelines

● **American Pipe Line Co.**—Received ODM approval to amortize 40 per cent of $178,000,000 with a rapid writeoff on proposed line from Gulf Coast area to New York City area.

Buckeye Pipe Line Co.—Will complete in July 1956, conversion of 32 miles of 8-in. crude line between Mantau and Ellsworth, Ohio, to products line.

● **Cities Service Oil Co. & Subsidiaries.**—Plans a 10-mile, 6-in. L.P.G. line from Maysville to near Pauls Valley, Okla., to tie in to Shell line moving on to Cushing, Okla.

Cosden Petroleum Co.—Let 100 miles of 6-in. from Big Spring to Abilene, Tex., to C. O. Holder Construction Co. of Snyder, Tex., to be completed April 30, 1956.

● **El Paso Natural Gas Co.**—Plans 240 miles of "larger than 6-in." to carry natural gasoline, butane, and propane, from its Midkiff natural-gasoline plant in Permian basin, Midland County, to El Paso.

● **Gulf Refining Co.**—Will build 45 miles of 8-in. from Pontiac Eastern Corp.'s planned refinery at Hattiesburg, Miss. (due on stream May 1957) to a connection with Plantation Pipe Line Co.'s system. No date set to start.

Interstate Oil Pipe Line Co.—Let 25 miles of 8-in. from 12 miles south of Shreveport to Bethany, La., to C. Wayne Fowler, Pipe Line Contractor, Ins., to be completed June 1, 1956.

● **Magnolia Pipe Line Co.**—Plans a 75-mile, 8-in. L.P.G. line from Hull to Texas City, Tex., and a 30-mile, 8-in. line from Andrews to Dollarhide, Tex., both to be completed January 1, 1957. Plans an L.P.G. line, 19 miles of 6-in., 3 miles of 4-in., from Beaumont to Orange, Tex. Completion date indefinite.

● **Phillips Chemical Co.**—Plans 79 miles of 6-4-in. ethylene line from Sweeny to Pasadena, Tex., to be completed December 31, 1956.

● **Phillips Petroleum Co.**—Plans 15 miles of 6-in. L.P.G. line in Sweeny, Tex., area, to be completed September 15, 1956, and 16 miles of 3-in. product in Central Oklahoma area, to be completed June 1, 1956.

● **Phillips Pipe Line Co.**—Let 64 miles of 12-in. from Sweeny, Tex., to Houston, to be completed June 1, 1956, by H. H. Null. Plans 135 miles of 12-in. looping between Borger, Tex., and St. Louis, Mo., to be completed December 31, 1956.

Plantation Pipe Line Co.—Let 327 miles of 18-in. from Baton Rouge to Helena, Ala., to Oklahoma Pipe Line Constructors, to start June 1. N. L. Arie, spread superintendent, office at Baton Rouge. Completion set for December 1956.

● **Shell Oil Co., Pipe Line Department, Pacific Coast.**—Plans to convert 13 miles of existing 4-in. gasoline line, and add 3 miles of new line, to move gasoline from Wilmington refinery to Los Angeles. To be completed January 1, 1957.

● **Sioux Oil Co.**—Plans 80 miles of 4-in. from its Newcastle, Wyo., refinery to Rapid City, S. D., to be completed late 1956.

● **Southern Pacific Pipe Lines, Inc.**—Plans a line to span the Sierras and connect San Francisco with Reno and Fallon, Nev., and to serve the Sacramento Valley.

Sun Pipe Line Co.—Contracts let on 109 miles of 14-in. from Twin Oaks, Pa., to Newark, N. J.: Sheehan Pipe Line Construction, 90 miles from Twin Oaks to Plainfield, N. J.; Delaney-Missouri Valley Construction Co., remainder. Work to start May 1, end

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September 1956. The line, with 83,000-bbl. capacity, will replace present 8-in. line.

• **Sunflower Pipe Line System.**—Has Kansas Corporation Commission approval for 215 miles of 6-in. to move L.P.G. from six counties in western Kansas to Wichita.

Tennessee Gas Transmission Corp.—Contracts let for 200 miles, 6-in. L.P.G. line from Banquete, Tex., to Houston: Sheppard & Geiger Construction Co., section from Banquete to Port Lavaca; Oklahoma Pipe Line Constructors, 74 miles from there to Brazos River, Gene Gohring, spread superintendent, office at Bay City; Panama-Williams Co., section into Houston.

Texas Eastern Transmission Corp.—Has approval to abandon "Little Inch" gas line, convert it to products line with capacity of 235,000 bbl. daily.

Non-Petroleum Pipelines

• **American Gilsonite Co.**—Plans 70 miles of 6-in. from Bonanza, Utah, to Grand Junction, Colo., to carry slurry of gilsonite from mines to refinery now being built.

Pittsburgh Consolidated Coal Co.—Let to Williams Brothers, 108 miles of 10-in. from its mines in eastern Ohio to Cleveland Electric Illuminating Co.'s Eastlake power plant northeast of Cleveland. Work started April 1, 1956, on this first line to move coal, with Ford, Bacon & Davis, Inc., handling specifications, contracts, construction supervision.

Natural-Gas Pipelines

American Louisiana Pipe Line Co.—Let bulk of 1,160-mile line from North Tepetate, La., to Detroit. H. C. Price and Houston Contracting Co. have 770 miles of 30-in. from near Willow Run, Mich., to near Eudora, Ark. Work starts June 1 on 40 miles in Ohio, E. C. Norris, spread superintendent, office at Defiance. Work starts May 1 on 100 miles from east of Memphis, Tenn., to near Eudora, Ark., W. H. Hayes, spread superintendent. Works starts May 15, on 85 miles working north from Eudora, F. A. Silar, spread superintendent. Brown & Root has 221 miles of 30-in. from North Tepetate to Arkansas-Louisiana border (which is subcontracted to Associated Pipe Line Contractors and Western Contractors), and 39 miles of 16-in. under-water line which it will lay itself. Western Contractors experts to complete its 100 miles August 1956. W. B. Williams, spread man, office at Eunice.

• **Arkansas Louisiana Gas Co.**—Has long-range plans for line from Texas-Louisiana coastal region to northern Louisiana, to connect with their present system.

Atlantic Seaboard Corp.—Williams-Austin Co. has under way 50 miles of 24-in. from Hardy County, South Virginia, to Greene County, Virginia. O. L. Martin, spread man, office at Elkton, Va.; and 37 miles of 26-in. loops along the Cobb-Rockville line in West Virginia. Ralph Gaddy, spread man, office at Elkins, W. Va.

• **Carolina Pipeline Co.**—Applied for South Carolina Public Service Commission permit to distribute gas in central South Carolina. Plans lines to 14 cities. Will buy gas from Transcontinental Gas Pipeline Co. or Southern Natural Gas Co.

• **Carolina Natural Gas Corp.**—Proposes 185 miles of 8-12-in. laterals off Transcontinental in North and South Carolina.

Cascade Natural Gas Co.—Engineering Construction Co. started April 1, 1956, laying 400 miles of ¾ to 12-in. distribution lines in Yakima, Grandview, Granger, Trosper, Sunnyside, Toppenish, Union Gas, Wahpato, and Zillah, Wash.

Cities Service Oil Co. & Subsidiaries.—M. L. Moore Construction Co. has 18 miles of 3 to 10-in. gathering system at Roberts Ranch near Odessa, Tex., to be completed June 15, 1956.

• **Coastal Transmission Corp.**—Applied to FPC for 565 miles of 22-26-in. from McAllen, Tex., to Baton Rouge, to deliver to Houston Texas Gas & Oil Co.'s proposed line to Florida. Plans 272 miles of smaller gathering lines.

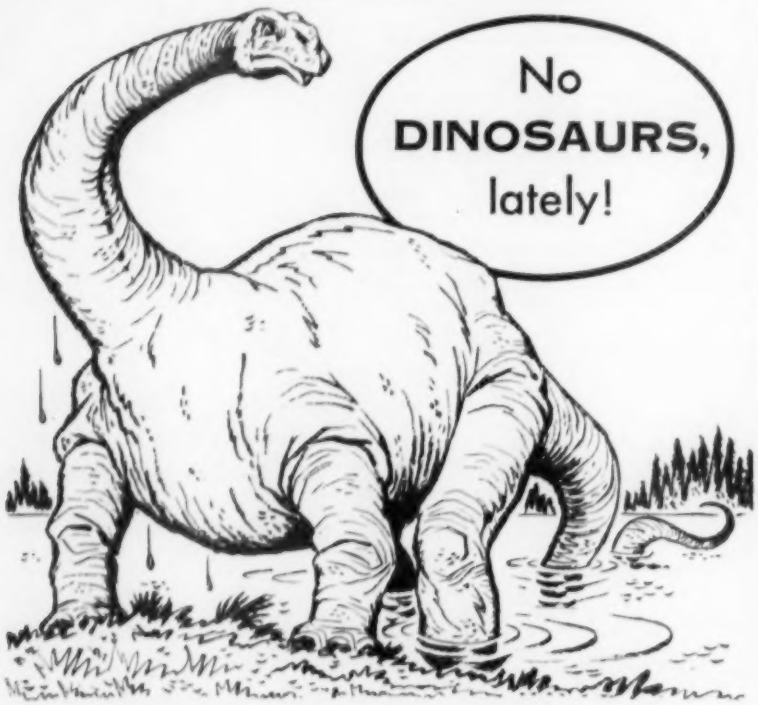
• **Colonial Natural Gas Corp.**—Proposes two systems: One between Houston-Lake Charles area and Miami, Fla.; one in the Carolinas and Georgia.

• **Colorado Interstate Gas Co.**—R. H. Fulton has 238 miles of 22-in. from Laramie to Green River, Wyo. (last part of a 374-mile line between Denver and Rock Springs), to be completed fall 1956. Filed, March 29, for FPC permit for 1957 program: 307 miles of 30-in. from Idalia, Colo., to Beatrice, Neb., to take gas from a planned 165-mile, 26-in. line from near Carr, Colo., to Idalia, and from a 72-mile, 26-in. line from near Kit Carson, Colo. to Idalia; 215 miles of 20 and 24-in. to parallel present line from Texas Panhandle area to Kit Carson; 34 miles of 16-in. from Keyes field, Oklahoma, and Greenwood field, Kansas, to the new north-south line.

• **El Paso Natural Gas Co.**—Has FPC permit to loop 450 miles of 34-in. from San Juan basin to the Colorado River at Arizona-California border.

• **Empire Southern Gas Co.**—Plans a 10-mile, 8-in. line, and 5 miles of 4-in. gathering lines in Gray County, Texas, to be completed August 15, 1956. Plans a 4-mile, 8-in. loop south cut of Pampa, Tex., on transmission line, and a 9-mile, 8-in. loop northwest out of Big Spring, Tex., on transmission line, to be completed September 1, 1956. Plans 6 miles of 4-in. near Big Spring, to be completed June 1, 1956.

• **Houston Texas Gas & Oil Co.**—Applied



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to FPC for 960 miles between Baton Rouge and Miami: 507 miles of 30-in., 157 miles of 26-in., 61 miles of 20-in., 224 miles of 18-in., 12 miles of 12-in. Plans 500 miles of sales laterals in Florida, with main line joining Coastal Transmission's proposed line from McAllen, Tex., to Baton Rouge.

• **Iron Ranges Natural Gas Co., St. Paul.**—Applied to FPC for a 68-mile transmission line and 47 miles of laterals to supply towns on the Mesabi Iron Range, Minnesota.

• **Kansas-Nebraska Natural Gas Co., Inc.**—Plans 11 miles of 12-in. from Colby to Oakley, Kans., to be completed August 1956. Plans 10 miles of 10-in. and 10 miles of 8-in. from Grand Island to Albion, Neb., to be completed November 1956. Plans 30 miles of 4-in. laterals to Eckley and Wray, Colo., to be completed July 1956.

• **Lone Star Gas Co.**—Has two plans before FPC to enlarge system in Texas and Oklahoma: one is a 230-mile line from Cotton County, Oklahoma, to Fritch, Tex.; one is a 205-mile line from Snyder, Tex., to a hookup with the Cotton-Fritch line. Plans are attempt to keep Natural Gas Pipeline Co. of America from building line from Wise County, Texas, to Fritch.

• **Michigan Consolidated Gas Co.**—Plans 62 miles of 12-10-in. from Muskegon to Ludington, Mich., and 67 miles of 12-10-in. from Lake George to Travers City, Mich., both to be completed July 15, 1956.

• **Michigan Wisconsin Pipe Line Co.**—Proposes 251 miles of 24, 18, 12, 6, and 4-in. loops in Wisconsin.

• **Midwestern Gas Transmission Co.**—Will build a main line from Portland, Tenn., to Canadian border near Emerson, Man.; 829 miles of 24-in., 109 miles of 16-in., 174 miles of 12-in. Plans 648 miles of 3 to 18-in. extensions in Minnesota and Wisconsin, pending FPC approval.

• **Natural Gas Pipeline Co. of America.**—Has FPC approval for 350 miles of 20 and 26-in. from Jack and Wise counties, Texas, to Fritch, Tex., which will be contested by Natural Gas Pipeline and Lone Star Gas Co. Filed for FPC permit for a 389-mile, 36-in. loop along its line from Beatrice, Neb., to Chicago, to take gas from proposed line of Colorado Interstate Gas Co. Also for 91 miles of 30-in. looping to be laid along parts of its main line.

Nevada Natural Gas Co.—Plans loops along its 114-mile line from Needles, Calif., to Las Vegas, Nev.

New York State Natural Gas Corp.—Williams-Austin Co. has 17 miles of 30-in. from Caton to Horseheads, Steuben County, New York, to start July 9, 1956. Harford Brothers has 27 miles of 20-in. from Elk County to Clearfield County, Pennsylvania, to be completed June 15, 1956.

Niagara Mohawk Power Corp.—Let to various contractors, 275 miles of 2 to 12-in. distribution mains for growth of service areas in Central, Eastern, and Northern New York, to be completed December 31, 1956.

• **North Carolina Natural Gas Corp.**—This subsidiary of Colonial Natural Gas Corp. has permit from North Carolina Utilities Commission for 575 miles of 3 to 16-in. from Transcontinental Gas Pipe Line Corp.'s system near Mooresville, eastwardly across North Carolina.

• **Northern Natural Gas Co.**—Applies to FPC to add 348 miles of main line, 307 miles of branch lines in Wisconsin, Minnesota, South Dakota, and Iowa. Main lines include 169 miles in Duluth-Superior area, 164 miles in Aberdeen area of South Dakota. Proposes 73 miles of 20-in. from Savanna Creek to Pincher Creek fields in Alta., Canada; 32 miles of 24-in. from Pincher Creek to Montana border; 1,100 miles of 26-in. from Montana into Minneapolis.

• **Pacific Gas & Electric Co.**—Will build 37 miles of 20-in., 37 miles of 18-in., 9 miles of 12-in. from Beehive Bend field near Willows, Calif., to near Davis, then to Sacramento. Has under way a 6-mile gathering system at Beehive Bend. Also plans to loop the Topock-Milpitas line with 135 miles of 34-in., laying major part in 1956, and 62 miles in 1957.

• **Pacific Northwest Pipeline Corp.**—Has FPC permit for 37 miles of 6-in. from Dove Creek, Colo., to Nucla, and 13 miles of 4-in. from Nucla to Uravan, to serve Union Carbide Nuclear Co. and Vanadium Corp. of America. Contracts let on other trunk and sales laterals:

A. P. V. Co., Inc., 81 miles 26-in. between Plymouth and Goldendale, Wash.

Engineers Limited, Inc., 56 miles 26-in. between Goldendale and Stevenson, Wash.

Midwestern Constructors, Inc., 79 miles of 26-in. from Skamania to Toledo, Wash., to be completed July 1, 1956. M. T. Wilhite, spread man, office at Camas, Wash.

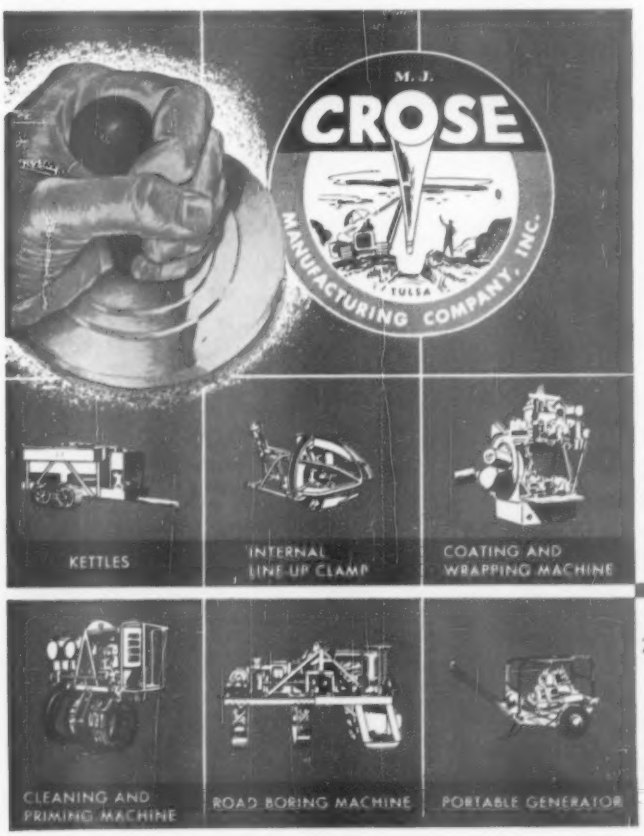
River Construction Corp., 64 miles 26-in. between Toledo and Tacoma, to be completed August 1, 1956, Vernon Gayhart, spread man, office at Vancouver, Wash.; also 16 miles of 18-in. out of Portland, Ore., to be completed May 1, 1956, Vernon Gayhart, spread man, office at Centralia, Wash.

B & M Construction Co., 53 miles 26-in. between Tacoma and Duvall, Wash.

Curtis Construction Co., 87 miles 26-in. between Duvall and Sumas, Wash.

Hood Construction Co., 31 miles 6-in. near Walla Walla, Wash.

R. H. Fulton & Co., 156 miles 20 and



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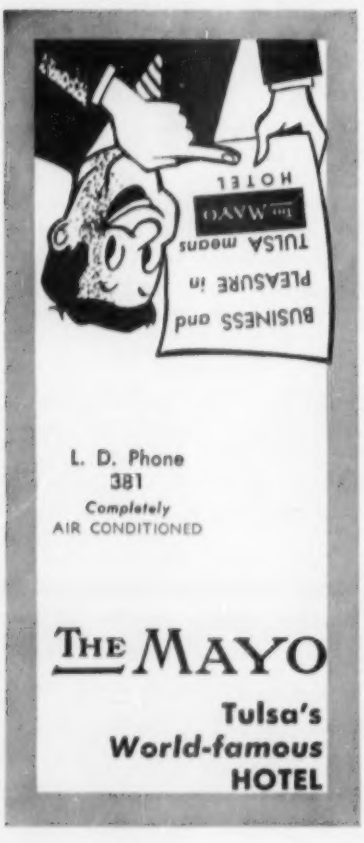

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16-in. lateral from main line to Spokane; also 129 miles of laterals into Idaho.

Eastern Pipeline Contractors, 137 miles of 6, 8, 10-in. laterals from Plymouth to Wenatchee, Wash., to be completed July 1, 1956, L. Visentine, spread superintendent, office at Yakima.

Penn Fuel Gas Co.—Sheehan Pipe Line Construction Co. has 25 miles of 8-in. from Lewistown to Cross Keep, Pa., to be completed May 1, 1956, J. W. Brown, spread superintendent, office at Lewistown.

• **Permian Basin Pipeline Co.**—Has applied to FPC for 19 miles of 16-in. in Andrews County, Texas.

Phillips Petroleum Co.—Vaughn & Taylor has 135 miles of 20 to 2-in. gathering line in Central Oklahoma, to be completed June 1, 1956, and, with McVean & Barlow, 325 miles of 24 to 2-in. gathering line in West Texas, to be completed July 1, 1956.

Portland Gas & Coke Co.—United Engineers & Constructors, Inc., of Philadelphia, has engineering contract for 80 miles of various size lines up to 16-in.

Signal Oil & Gas Co.—C. P. Bartley & Son has 70 miles of 2 to 16-in. gathering system near Tioga, N. D., to be completed September 1, 1956. C. P. Bartley, Jr., and Lawrence Barto, spread men, office at Tioga.

• **Southern California Gas Co. and Southern Counties Gas Co. of California**—Plan three jobs: 19 miles of 30-in. from Placentia to Compton, Calif., to be completed November 1956; 70 miles of 30-in. from Palmdale to Alhambra, Calif., to be completed November 1956; 210 miles of 30-in. from Topock to Palmdale, to be completed April 1957.

• **Southern Natural Gas Co.**—Has temporary FPC authority for 39 miles of loops near Atlanta, Ga.

• **Tennessee Gas Transmission Co.**—Projects:

192 miles of 24-in., 34 miles of 20-in., 15 miles of 18-in., 110 miles of 4, 6, 8, 10, and 12-in. laterals to extend gathering system from west of Crowley, La., to tie in to Tennessee Gas gathering line, eastward across southeast Louisiana, to mouth of Mississippi River, with laterals extending into Gulf of Mexico.

Contracts let: Houston Contracting Co. has 162 miles in southern Louisiana; 25 miles of 24-in. completed; 25 miles of 24-in. marine line including the Atchafalayaz River crossing, to be completed May 15, spread superintendent, E. C. Norris, office at Morgan City; 25 miles of 24-in. marine line southwest of Cocodrie, spread superintendent, H. E. Murphy; 25 miles of 8 and 10-in. laterals south of Morgan City, to be completed May 5, spread superintendent, R. L. Silar; section east of Jeanerett toward Leeville.

Williams Brothers Co. has 55-mile, 24-in. marine job from Cocodrie, La., east of Bay Chalon area, spread man, W. A. Briley.

Grayco Constructors, Inc., Associated Pipe Line Contractors, Inc., and Collins Construction Co. have remainder.

Has FPC permit for 74 miles of 30-in. looping from Cave City to Danville, Ky., and for 147 miles of 26-in. looping from east of New Boston, Ohio, and north of Ohio River to McConnellsville, and from Newcomerstown to Lisbon, Ohio, both to be completed fall of 1956.

Applied for FPC permit for 63 miles of 30-in. looping from Scottsville, Ky., to Cave City, and from southwest of Danville to northeast of Danville; for 99 miles of 26-in. looping from Greenup, Ky., to north of Ohio River, from McConnellsville to Newcomerstown, and from Lisbon, Ohio, to near Mercer, Pa.; for 100 miles of 4, 6, 8, 10, and 12-in. gathering line in Texas-Louisiana Gulf Coast area.

Tennessee Natural Gas Lines, Inc.—Walters & Prater has 9 miles of 12-in. looping including Cumberland River Crossing, Tenn., to be completed July 1, 1956.

Texas Eastern Transmission Co.—Has FPC permit to convert its Little Inch gas line to products. Applied to FPC, December 1955, for 422-miles of 30-in. from McAllen to Beaumont, Tex., to move imported Mexican gas. Applied for 530 miles of 30-in. looping from Kosciusko, Miss., to Uniontown, Pa. Will lay 45 miles of 24-in. from Provident City, Tex., to connect in Matagorda County, Texas, to tie the Wilcox Trend Gathering System with the extension from Mexico.

• **Texas Gas Transmission Corp.**—Plans 110-mile, 20-in. from Assumption Parish to near Eunice, La. Will also lay 40 miles of various size pipe along main line from Louisiana to Illinois. Both to be completed December 1956. Plans 53 miles of 30-in. from Chicot, Ark., to Clarksdale, Miss., to be completed September 1, 1956. Plans reconditioning of 21 miles of 18-in. line near Wilmot, Ark., and Clarksdale, Miss., to be completed October 1, 1956. Williams Brothers Co. has 9 miles of 26-in. near Whitesville, Ky., to be completed May 31, 1956.

• **Trans Carolina Pipe Line Corp.**, Commercial Building, Raleigh, N. Car.—Seeks FPC permit for 300-mile system across North and South Carolina, plus 500 miles of laterals.

• **Transcontinental Gas Pipe Line Corp.**—Has applied to FPC to lay 160 miles of 36-in. and 68 miles of 30-in. loops from Louisiana to Pennsylvania., to be completed December 1, 1956.

Ashby Construction Co. has 11 miles of 12 and 16-in. gathering line in Vermilion Parish, Louisiana, to be completed April 30, 1956.

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Foreign Crude-Oil Pipelines

Arabian American Oil Co.—Firm is building a 150-mile, 21-in. line from Safaniya field to near the Neutral Zone border.

• **Cremona Pipe Lines, Ltd.**—Dutton-Williams Brothers, Ltd., has 60-mile, 8-in. line from Sundre-Westward Ho region to Calgary, to be completed July 1956. Company is subsidiary of Home Oil Co.

Creole Petroleum Corp.—Williams Brothers Sudamericano, Ltd., has under way 15 miles of 34-in. from Pueblo Viejo to Lagunillas, Venezuela, to be completed August 1, 1956.

• **Esso, A. G.**—West Germany affiliate of Standard Oil Co. (N.J.). Plans line from North Sea port to Rhur-Rhine area—probably 120 miles of 10-in. from Rotterdam to Cologne where, it is rumored, Esso will build a new refinery.

Ganso Azul Cia de Petroleo.—Building 47-miles of 4-in. from Agua Caliente field to Pucallpa on the Ucayali River.

• **Gulf Italia Co.**—Will complete late summer 1956, 35 miles from its Ragusa field in southwestern Siciliy to RASIOM's refinery at Augusta.

Interprovincial Pipe Line Co.—Let to Majestic Contractors, Ltd., 69 miles of looping along present system from Alberta to Sarnia, Ont., to be completed August 31, 1956: 67 miles of 24-in. between Carroll and Somerset, Man.; 2 miles of 26-in. between U. S. border and Gretna pumping station.

Peace River Oil Pipe Lines, Ltd.—Dutton-Williams Brothers, Ltd., has 35 miles of 8-4-in. gathering system at Sturgeon Lake, Alta., to be completed July 1956, Jack Engleking, spread man, office at Valleyview.

• **Pembina Pipe Line, Ltd.**—Sparling Davis Co., Ltd., has 100 miles of 3 to 10-in. gathering system in Pembina field.

PEMEX.—Constructora El Aguila, S. A., has 50 miles of 20-in. from Angostura to Veracruz, Antonio Sanz Polo, spread man, office at Veracruz.

• **Sinclair Oil Corp.**—Considering a 240-mile line from its Silvestre field in Barinas, Venezuela, to Puerto Cabello on Caribbean Sea.

Westspur Pipe Line Co.—Majestic Contractors, Ltd., has 109 miles of 12-in. from Midale, Sask., to Interprovincial Pipe Line Co.'s pump station at Cromer, Man., and 50 miles of various size gathering lines in Midale-Frobisher area.

Yacimientos Petroliferos Fiscales (Argentina).—Has started 700 miles of 12-in. from Campo Duran to San Lorenzo. TECHINT, (Compania Tecnica Internacional), Buenos Aires, has 90 miles.

Yacimientos Petroliferos Fiscales Bolivianos (Y.P.F.B.)—Williams Brothers Co. has 160 miles of 10-in. and 43 miles of 8-in. from Sicasica to Arica on the Chilean coast, to be completed December 1957.

Foreign Products Pipelines

• **Canadian Hydrocarbons, Ltd., Winnipeg**—Proposes 800-mile LPG line from Edmonton, Alta., to Winnipeg.

• **Estrada de Ferro Santos a Jundial Departamento Oleoducto.**—Plans 6 miles of 14-in. from the Capuava Refinery to Utinga Terminal, to be completed December 1956.

• **Imperial Oil, Ltd.**—Will lay 38 miles of 12-in. loop along present line from Waterdown, Ont., to Toronto.

• **Iraq Petroleum Co., Ltd.**—Plans 75 miles of 24-in., 180,000-bbl. daily capacity, from Homs, Syria, to Tripoli, Lebanon.

National Iranian Oil Co.—Contracts let on 573 miles of 10-in., 40,000-bbl. daily capacity, from Ahwaz to Teheran, Iran; Constain-John Brown, Ltd., London, and Williams Brothers Co., started February 1956, laying southern 337 miles; Enterpose of Paris, has northern 236 miles.

• **North Atlantic Treaty Organization (NATO).**—Laying 2,000 miles of lines to airfields in parts of Europe. Associated Pipeline Contractors, Inc., has 450 miles from Iskenderun, Turkey, to Batman. TECHINT (Compagnia Tecnica Internazionale), Milano, Italy, has 205 miles of 4-in. from Bandirma to Eskisehir, Turkey, and 250 miles of 8-in. from Antalya to Eskisehir. Bids were taken in January 1956, on 300 miles of 12-in. between Marseille and Langres, France.

PEMEX.—Constructora El Aguila, S. A., has 155 miles of 12-in. from Tampico to Cd. Victoria, Geronimo Aviuchastegui, spread man, office at Tampico.

The United States Defense Department.—Sponsoring 485 miles of 8, 10, 12-in. from Cadiz to Zaragoza, Spain. Contracts let to Merritt Chapman & Scott; Benson & Montin of Oklahoma City; Agroman Construction Co. of Spain. Prime contractor is Brown-Raymond-Walsh.

Yacimientos Petroliferos Fiscales Bolivianos (Y.P.F.B.)—Williams Brothers Co. has 190 miles of 4-in. from Camiri to Santa Cruz, to be completed December 1956.

Foreign Natural-Gas Pipelines

• **Alberta Gas Trunk Line Co.**—Plans 547 miles of gathering system for the Trans-Canada line: 219 miles, to be completed in 1956, near Saskatchewan and including Pincher Junction, Provost, Bindloss, Sibbald, Oyen, Sunnynook, Steveville, and Cessford; 328 miles, to be completed in 1957, will include Countess, Duchess, Princess, Homglen-Rimbey, and Nevis.

Attock Oil Co.—Plans 60 miles from Dhulian field to Rawalpindi in West Pakistan.

Cia. Shell de Venezuela.—Plans 177 miles of 20-in. from La Paz field in the Maracaibo district, to the Cardon refinery on Paraguana Peninsula, to fuel refinery furnaces. To be completed in 1957.

• **Estrada de Ferro Santos a Jundial Departamento Oleoducto.**—Plans 16 miles of 6-in. from Cubatao refinery to Elcloro plant, to be completed December 1956.

• **Gas Industrial de Monterrey.**—Plans 130 miles of 22-in. to parallel a 14-in. line from Reynosa to Monterrey in northern Mexico.

Imperial Oil, Ltd.—Has let 65 miles of 4 to 16-in. gathering system in Redwater area of Alta., to Majestic Contractors, Ltd.

• **Magna Pipeline Co.**—Plans to complete fall 1956, an underwater line from Anacortes or Bellingham, Wash., to Victoria.

Mid-Western Industrial Pipe Lines, Ltd.—Dutton-Williams Brothers, Ltd., has 33 miles of 10-in. from Alexander Indian Reservation to Lake Wabamun, to be completed June 1956, L. A. Stewart, spread man, office at Edson, Alta.

North Canadian Oils, Ltd.—Dutton-Williams Brothers, Ltd., has 136 miles of 10-in. from Lake Wabumun to Hinton, Alta., to be completed September 1956, L. A. Stewart, spread man, office at Edson, Alta. Crossings of the McCleod River, Pembina River, and Wolf Creek are being made early.

South Alberta Pipe Line, Ltd.—Filed permit for 150 miles of 8-in. from Etzikom field to serve a nitrochemical plant to be built near Medicine Hat, Alta.

Sui Gas Transmission Co.—Pakistan Constructors, a joint company of Morrison-Knudsen of Boise, Ida., and William Press, Ltd., of London, have 188 miles of 16-in. from Sui gas field to Moultan, Pakistan. Work begins mid-1956. Line to be extended later to Lahore with branches at Kot Addu, Jhang, Magiana, and Montgomery.

• **Trans-Canada Pipe Lines, Ltd.**—Time limit to complete financing a 2,250-mile line from Alberta to Toronto and Montreal, is extended to November 1, 1956. New deadline for exporting gas from Alberta is December 31, 1957. Ontario government will help finance line through its province. Tennessee Gas Transmission Co. has proposed a line to take the gas at Emerson, Man. (See Midwestern Gas Transmission Co).

Westcoast Transmission Co., Ltd.—Has let 650 miles of 30-in. from Peace River area, Canada, to Sumas, Wash. Dutton-Williams Brothers, Ltd., has 120 miles from Taylor, B. C., to Azouzetta Lake, to be completed August 1957, E. J. Roth, spread man, office at Dawson Creek, B. C. Mannix, Ltd., Canadian Bechtel, Ltd., and R. A. Conyes Construction Co. have remainder, to be completed September 1957.

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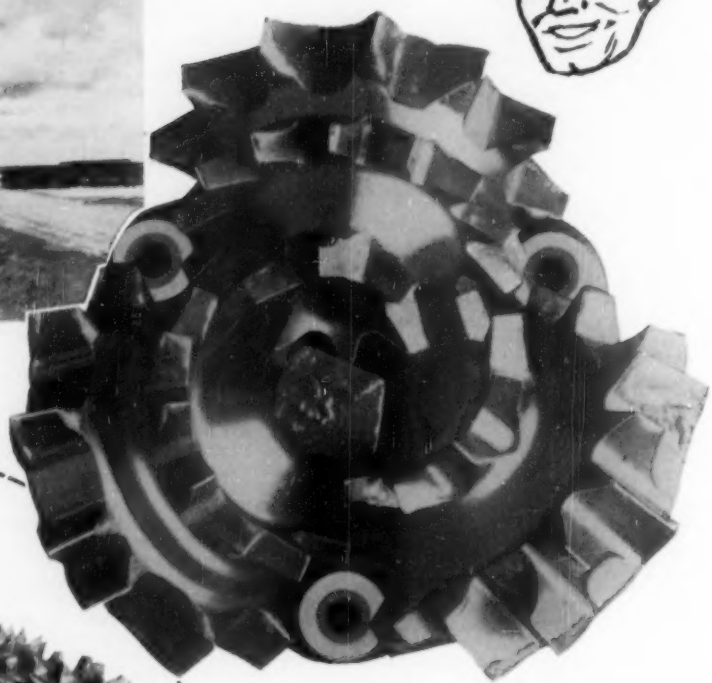

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Among the

Drilling Contractors

Regional Safety Clinic Scheduled for Casper

A "down-to-earth" program of sound, workable, and practical safety recommendations for the drilling industry is being set up for the second annual Rocky Mountain regional safety clinic at the Gladstone Hotel, in Casper, Wyo., May 11 and 12.

The two-day session is sponsored by the Casper chapter of the American Association of Oilwell Drilling Contractors. It will augment the 34 area safety clinics which the parent association, headquartering at Dallas, plans to hold this year.

The clinics are under the over-all supervision of the association's safety committee, headed by W. S. Fitzpatrick, of Fitzpatrick Drilling Co., Corpus Christi, Tex.

The regional clinic at Casper is aimed at supervisory and top-management personnel. The 34 area clinics are designed primarily for field personnel.

Principal speakers for the regional clinic include: Harry Hillman, California Production Service, Long Beach; W. W. Duncan, Oklahoma City, and John Jorgensen, Casper, safety directors for Loffland Brothers Co.; Sgt. Roger Wasson, Wyoming Safety Patrol; Bill Daniels, Denver insurance man, editor of the association's insurance manual; K. K. Swanson, safety director, Moran Drilling Co., Wichita Falls, Tex.; J. E. Harrington, safety engineer, General Petroleum Corp., Los Angeles; W. D. Powell, safety engineer, Fireman's Fun Insurance Co., Denver; Jim Muir, safety director, General Petroleums, Ltd., Calgary, Alta.; and I. J. Fisher, the association's national safety director, Dallas.

Thomas L. LaMore, True Drilling Co., Casper, is chairman of the clinic. Other local committee chairmen are: Guy Keith, Delta Drilling Co., program; H. A. True, True Drilling Co., entertainment; John Jorgensen, safety; Jim Sprecher, housing; and Carl Heibucher, publicity.

Clyde Hall Drilling Co., Bakersfield, Calif., is drilling on another Richfield Oil Corp. wildcat test north of Wheeler Ridge field, in southwestern Kern County, California. Location of the new test, 58-13 ROC KCL G, in 13-11-20, is slightly less than a mile northeast of a 7,869-ft. dry hole drilled for Richfield last November.

Miller Drilling Co., Jackson, Miss., is drilling Norton Oil Co., Inc., of Shreveport, and its own account at a wildcat location, 1-D Madison, in 6-5n-8e, 2¾ miles northwest of Quinn Bayou field, in Central Concordia Parish, eastern Louisiana. Drilling is projected to the Wilcox about 6,700 ft.

Baird & Pfeifer, Johnie Carter, and **Don Johnston Drilling Co.,** Denver, have rigs working for Frank Landauer & Associates in the new Orchard field, Morgan County, northeastern Colorado. The field now has two wells, one the discovery well with production from the "J" sand, and the other a new-pay discovery in the "D" sand. Baird & Pfeifer's rig is completing the third well. Johnston's rig is nearing the pay level for the field's fourth well. Carter is just getting started on another well.

Bowman Drilling Co. is contractor on a 6,000-ft. Mesaverde wildcat test scheduled for the Oil Springs area, 6 miles west of Dragon, in Uintah County, northeastern Utah. Sky-Hi Oil Co. is the operator. Location of the test, 1 Oil Spring, is in 14-12s-24e.

R. L. Manning Co., Denver, has contracted for an 8,000-ft. Tensleep test to be drilled for Continental Oil Co. in the Little Polecat area, 8 miles northwest of Garland, in northern Park County, in the Big Horn Basin, northwestern Wyoming. Location is on government land, in 25-57n-99w.

Delta Drilling Co., Tyler, Tex., is moving in for a 9,250-ft. Cotton Valley test it will drill for its own account in the Colquitt area, Claiborne Parish, northern Louisiana. Its location is for 1 U.S.A., spotted in 34-23n-6w.

Maxwell-Herring Drilling Co., Tyler, Tex., is on a new contract job 2 miles south of Brushy Creek, in Anderson County, East Texas. It is a 5,500-ft. test, 1 Elrod, for Hunt Granham and others. Location is in the James Hall Survey.

Pronto Drilling Co., San Antonio, is drilling for R. P. Rolland at a wildcat location 8 miles west of Carrizo Springs, in northwestern Dimmit County, Southwest Texas. The test is Holland's 1 Bray, in the John Sharp Survey. The contractor has another new wildcat operation under way in Frio County, also in Southwest Texas, where

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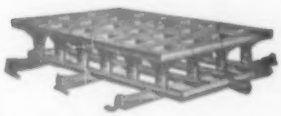

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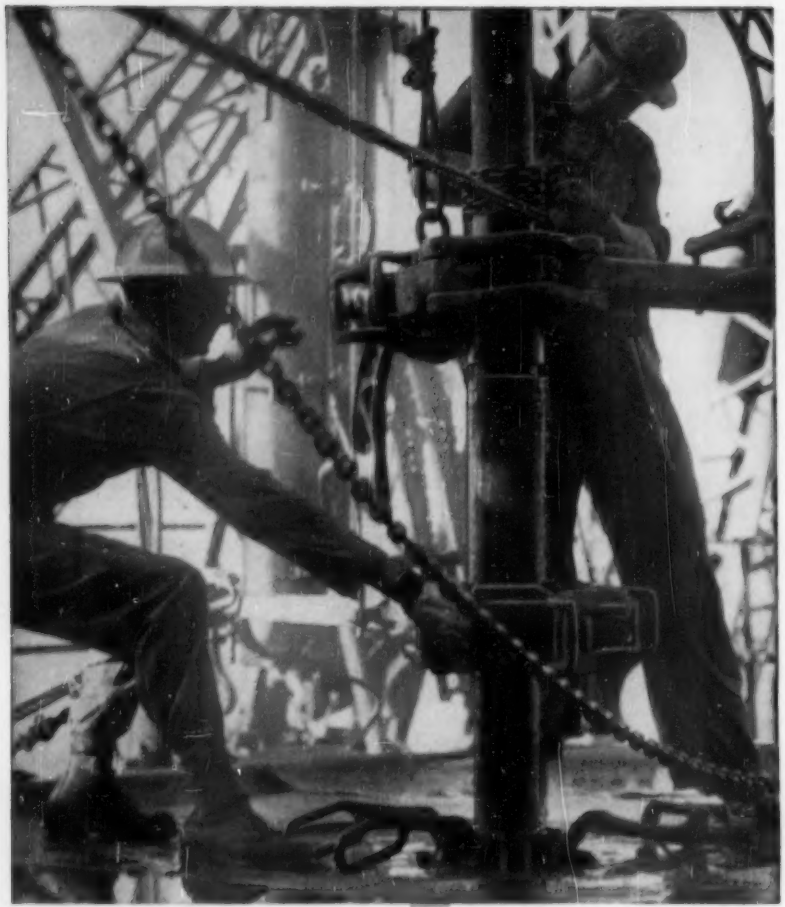

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it is drilling for its own account at 1 Bartlett, in the H. Castro Survey, 5½ miles east of Moore.

Talbert & Hughey Drilling Co., Tyler, Tex., is joint operator with J. L. Gulley, Jr., and contractor on a wildcat operation 1½ miles southeast of Pert, in Anderson County, East Texas. The test, 1 Weldon, in George Lester Survey, is projected to 5,600 ft.

Cactus Drilling Co., San Angelo, Tex., has a new deep wildcat operation in southern Lea County, New Mexico. It is a contract job for Monsanto Chemicals Co. Location at 1-D State, in 36-23-35, is 5 miles east of Bell Lake field. Planned depth is about 9,100 ft.

Milton Crow, Inc., Shreveport, has a new job for The Texas Co. in southwestern Arkansas. It is a 6,900-ft. Travis Peak test at 1 Hardy, in 13-19s-26w, 5 miles west of Bradley, in southern Lafayette County. Location is 3 miles northeast of West Bradley field, nearest production.

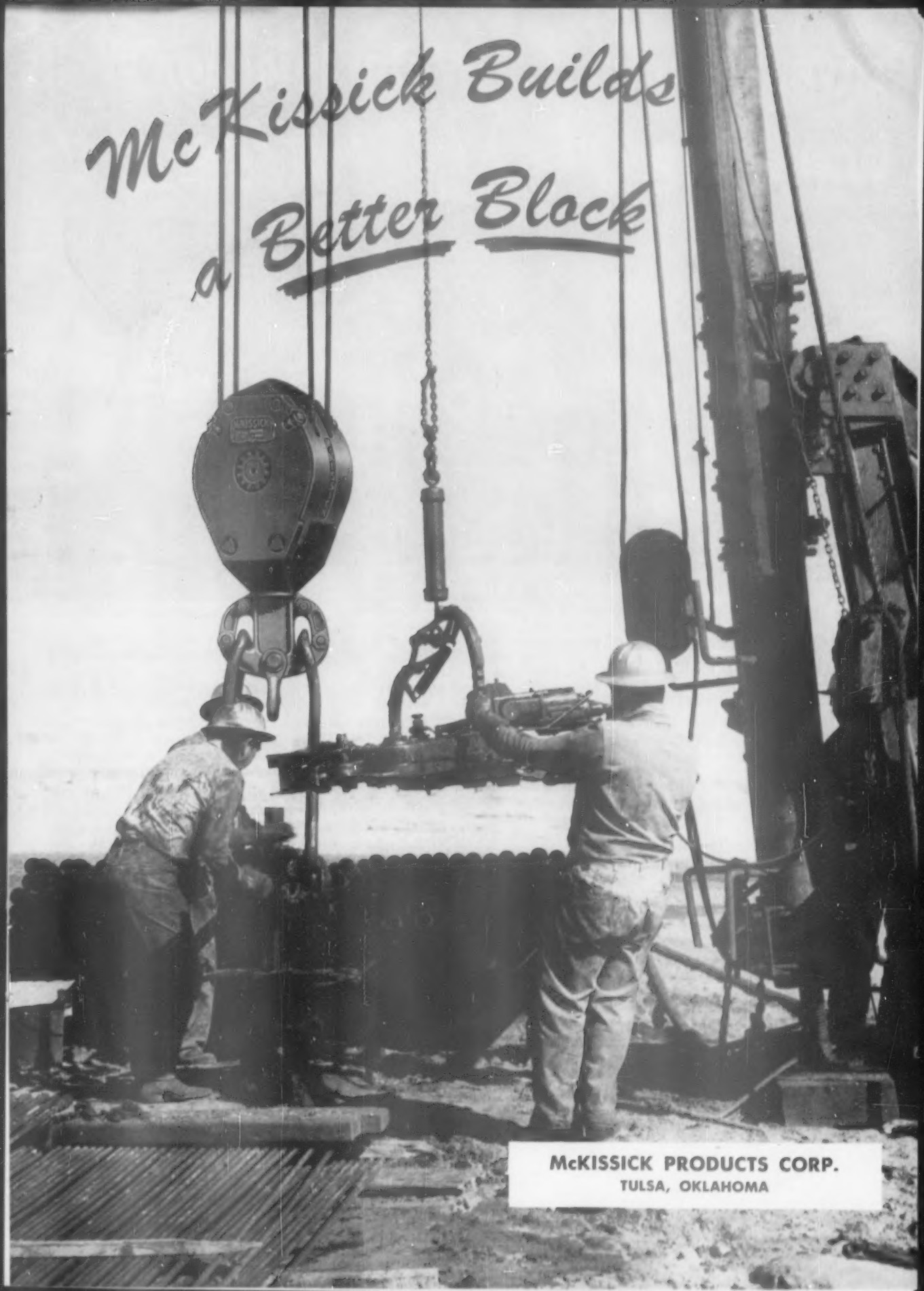
Trant Drilling Co. has a new 8,500-ft. operation under way for Carter-Gragg Oil Co. in the Wright Mountain area, 5 miles southwest of Gladewater, in Smith County, East Texas. Permit carries it as 1 Lena Gary, with location in the Oscar Hawkins Survey.

Greyhound Drilling Co. is starting another Travis Peak test for Arnold H. Bruner & Co. in the Bethany-Longstreet area, in De Soto Parish, northwestern Louisiana. Location is for 1 Swearingen, in 3-13n-15w. Objective is expected about 6,800 ft.

Halbert Drilling Co. has a 3,700-ft. job working for Tigner Walker and others at a wildcat location 2¾ miles southeast of Pleasant Hill, in Sabine Parish, North Louisiana. It is at 1 Etheridge, in 12-9n-12w. Objective is the Paluxy formation.

Sunnyland Contracting Co., Rayne, La., has contracted for a 5,600-ft. Wilcox test to be drilled for Gauthier & Heard, of Natchez, Miss., at a wildcat location a mile north of North Church Hill field, in Jefferson County, Mississippi. The test is listed as 4-1 Junkin. Spot location is in 20-9n-2w.

Admor Drilling Co. has a heavy-duty rig working for Gulf Oil Corp. at a wildcat location 7 miles southeast of Lefors, in Gray County, Texas Panhandle. Drilling is scheduled to be carried at least to 10,000 ft. Location, in Section 40, Block A-6, H&GN Survey, is 3 miles north of PH field.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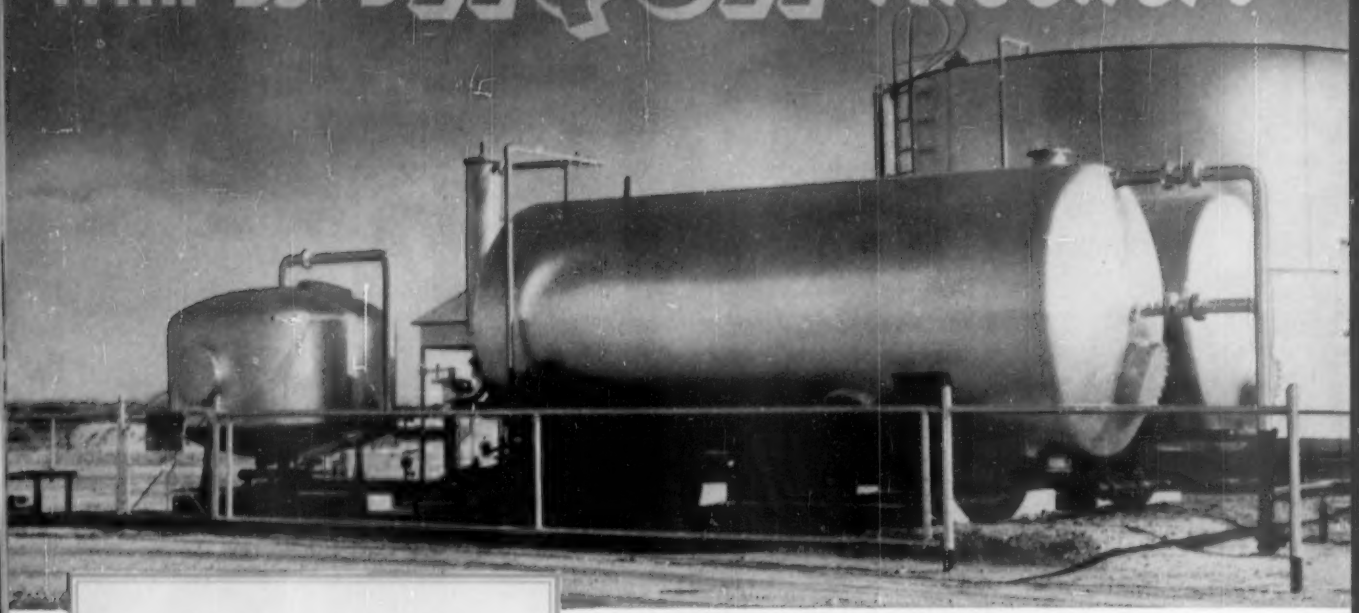

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EQUIPMENT MEN . . . in the News

Lane-Wells Names Kirkman Manager of Domestic Sales

C. L. KIRKMAN

C. L. Kirkman has been named manager of domestic sales for Lane-Wells Co., one of the Dresser Industries. In making the announcement, James D. Hughes, vice president for sales and service, pointed out that Kirkman will have charge of the company's sales activities in the United States.

Kirkman has been division sales manager for Lane-Wells Mid-Continent division, with headquarters in Oklahoma City. He joined Lane-Wells in 1937. He has held most of the positions in both operations and sales in the division.

S. C. Carter Co. Appoints Wickersham and Campbell

WICKERSHAM

N. W. Wickersham has been appointed regional sales supervisor for the Mid-Continent area, and Alex B. Campbell has been named sales engineer for California by S. C. Carter Co., Inc., Los Angeles, manufacturers of hydraulic pumping units.

Wickersham was formerly sales engineer in California. Campbell has had extensive experience in engineering and oil-field equipment.

Web Wilson Names Rocky Mountain Sales Assistants

The appointments of H. E. Mohr and A. W. Higgs to assist in sales in the Rocky Mountain area have been announced by R. K. Cooper, sales representative for Web Wilson Oil Tools.

From a new headquarters office in Denver, Higgs will cover the northern part of the territory from Casper, and Mohr will cover the southern part, including the Julesburg basin. Both men recently completed a training course at the Web Wilson plant and general offices in Los Angeles.

Homco Intensifies Directional Drilling Training

Homco's most recent class in directional drilling was graduated March 8. Instructors and trainee engineers participating in the school were: Edward A. Scown, assistant chief engineer for Homco and assistant director of training; Nathan Grantom; Ray Killman; B. H. Garrard; Armando Reed, J. W. Pogue, K. E. Wurzer, W. C. Patterson, George Lovelace, and L. L. Lyding, engineer trainees; L. H. Galleener, general manager, directional drilling department; and T. R. Texada, engineer trainee.

Houston Oil Field Material Co. initiated an employes training program in 1951 for directional-drilling engineers. In September 1955 the program, tentative at first, was enlarged and made permanent. Homco's policy is to put all new directional-drilling personnel through a rigid indoctrination and technical-training program prior to going into the field as directional-drilling engineers. Its aim is to give the trainee engineer a thorough understanding of the problems that he will face and the methods and tools available to him for solving these problems. This is accomplished through a copyrighted training manual providing for a uniform method of training.

The classroom phase of the program requires approximately 6 weeks of intensive work. Each of the basic headings in the outline covers many topics, and written examinations are given periodically to check progress.

Upon completion of the 6 weeks of classroom work, the engineer trainee begins the second phase, i.e., field or practical training. Each man is assigned to an experienced directional engineer. He continues in this phase until he is capable of performing his job to the satisfaction of his superiors. This phase requires an extended length of time.

Periodically, refresher courses are given to solve the new problems that constantly arise and to train the engineers in the use of new tools, equipment, and methods as they are developed.

National Supply Makes Allan Venezuela Manager

R. C. ALLAN

R. Carson Allan has been appointed manager for The National Supply Co. in Venezuela. He succeeds J. S. Blair, Jr., who recently was named sales manager, drilling equipment, with headquarters in Pittsburgh. The company operates in Venezuela through The National Supply Co. of Venezuela, C. A., a wholly owned subsidiary, with headquarters in Caracas. Offices are maintained at Caracas and Maracaibo, and the company has oil-field-supply stores at Anaco and Las Morochas.

Allan joined National Supply in 1938. From 1939 to 1947 he was with the engineering department of the Toledo plant. He was transferred to the export division in 1947 and appointed assistant division engineer in 1948, and division engineer in 1952. Since 1954 he has served as district manager in western Venezuela.

Shaffer Tool Acquires Office-Warehouse Building

Donald U. Shaffer, president of Shaffer Tool Works of Brea, Calif., has announced that the company has purchased a larger office and warehouse building at Avenal, Calif. The office and warehouse building covers 7,000 sq. ft. on an industrial site of approximately two acres.

Shaffer Tool Works has long been identified in the Kettleman Hills and

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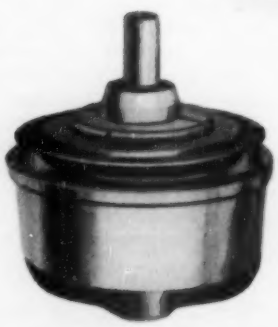

MISSION SUPER-CHROME PISTON RODS are your best buy because they give *more than* double service at *considerably less than* double cost. Like Mission File Hard Piston Rods, they are guaranteed against breakage.

MISSION SILVER TOP SLUSH PUMP VALVES feature replaceable bushings which reduce valve seat replacement costs. They are the most economical valves you can use when pump pressures do not exceed 1000 psi.

MISSION SUPER-SERVICE® SLUSH PUMP VALVES use the long life Compound 308® Inserts that have been proved superior over the years in both Silver Top and Super-Service® Valves. An extra strong valve seat design makes Super-Service® Valves suitable for higher pressures than Silver Top Valves.

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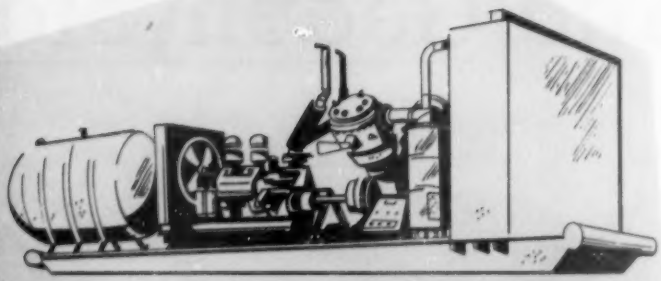

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Alexander Completes Vessel For Tidewater Marine

The High Tide, a 136-ft. offshore supply vessel recently launched at Alexander Shipyard, New Orleans, is one of the first completions in a heavy schedule for 1956. Launched on February 28, the vessel was designed and constructed for Tidewater Marine Service, Inc., of New Orleans.

The vessel has a 2,500-sq.-ft. deck space designed to carry drilling equipment to offshore drilling barges and platforms. In March the vessel went on location out of Morgan City, La., for Phillips Petroleum Co.

The main propulsion units are a pair of matched GM 6-110 tandem linked diesels, supplied by George Engine Co. of New Orleans.

Republic Picks Burks to Manage Louisiana District

ROSCOE BURKS

The opening of a new store at Morgan City, La., naming of Roscoe Burks as district manager with offices in New Orleans, and appointment of J. A. Kenner as store manager have been announced by M. N. Amsden, vice president and general manager of Republic Supply Co.

The location of the new Morgan City store is headquarters for much of the offshore drilling in the Louisiana coastal waters.

Carbide & Carbon Appoints Division Sales Managers

R. C. Boltz and J. E. Hulten have been appointed division managers, and

The guy on the right is Joe Roughneck. He's the brains and the brawn of the oil industry. Whether he is on a rig in the field or whether he has moved up to be president of his company . . . he knows oil . . . and pipe.

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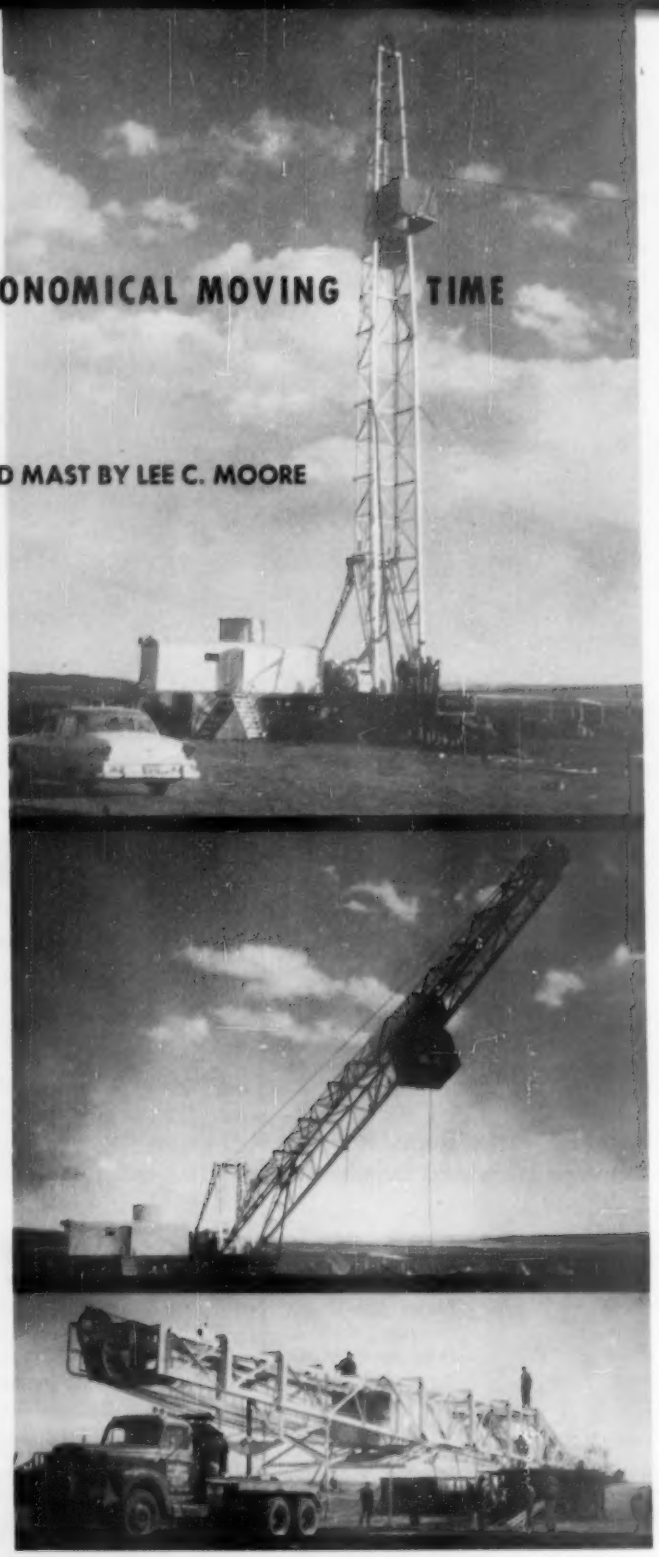

- Lee C. Moore announces a new 126-foot dual trailer mounted mast designed and engineered for both normal exploration drilling with standard 4½″ drill pipe and exploratory slim hole drilling. This mast offers greatest possible speed and economy in moving.
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- Complete mast and accessories with blocks strung, carried on one trailer and complete drawworks and power and compound carried on the other.
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Tulsa Nomads Organize Foreign Visitors Commitee

Seated: Howard Harmon, Pacific Valves; Jack Beesley, Baroid Division; Gerald H. Westby, Seismograph Service Co.; J. J. Young, Reed Roller Bit Co.; Ben F. Kelley, Ben F. Kelley, Inc. Standing: C. H. Keplinger, Keplinger & Wanenmacher; Don Collins, president of Nomads, Republic Supply Co.; Roy R. Bush, Rockwell Manufacturing Co.; Bob Glover, Baker Oil Tool; Oscar Irizarry, Petroleo Interamericano.

Tulsa Nomads foreign visitors committee recently attended an organization luncheon at the Tulsa Club. The purpose of the new committee is to contact and assist foreign nationals and American nationals employed in foreign fields while they are visiting in the Mid-Continent area.

H. P. White has been named assistant division manager for Carbide & Carbon Chemicals Co., a division of Union Carbide & Carbon Corp., according to E. E. Fogle, vice president of the company.

Boltz has been appointed eastern division manager and will be located in the New York office of the company. He was formerly manager for the Newark district.

Hulten has been appointed central division manager and will be located in Cleveland, Ohio. He was formerly district manager for the Philadelphia district.

White has been appointed Pacific Coast assistant division manager and will be located in San Francisco. He was formerly district manager for the Chicago district.

OBI Promotes Piskac, Appoints DeAinza

Charles L. Piskac has been promoted to assistant division manager in the Oklahoma, Kansas, Louisiana area, and Charles DeAinza has been appointed territorial manager of the San Joaquin area of California for Oil Base, Inc., Compton, Calif. Piskac, a former territorial manager, will headquarter at Houston. He will report to A. K. Brown, division manager.

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By Kenneth K. Landes, University of Michigan

This practical work provides useful field data on the occurrence, distribution, and technique of location of gas deposits and oil reservoirs—plus a clear explanation of the theories developed to explain the origin, migration, and accumulation of oil and gas. ". . . deserves commendation," say *Geophysics Magazine*, "for its many fine illustrations . . . ; its wealth of references, which completely document every facet of the discussion and indicate an amazing familiarity with the literature . . . ; and for the informal style of writing which keeps the material interesting in spite of a mass of facts and data that in the hands of a less skilled author would consign the book to dusty references shelves." 1951. 660 pages. $10.00.

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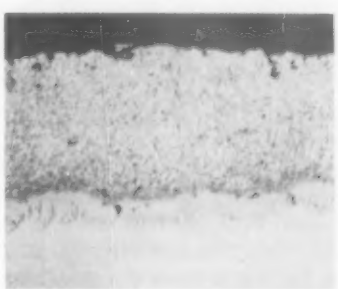

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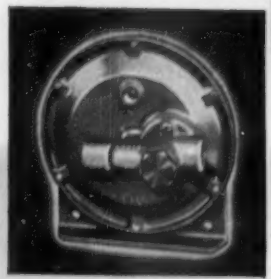
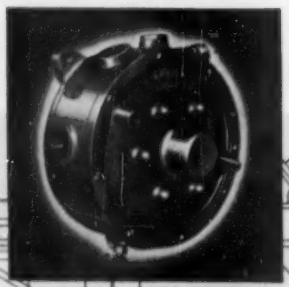
2. ECONOMY
3. DEPENDABILITY



VACUUM CONTROLLED SAFETY SHUT-OFF VALVE



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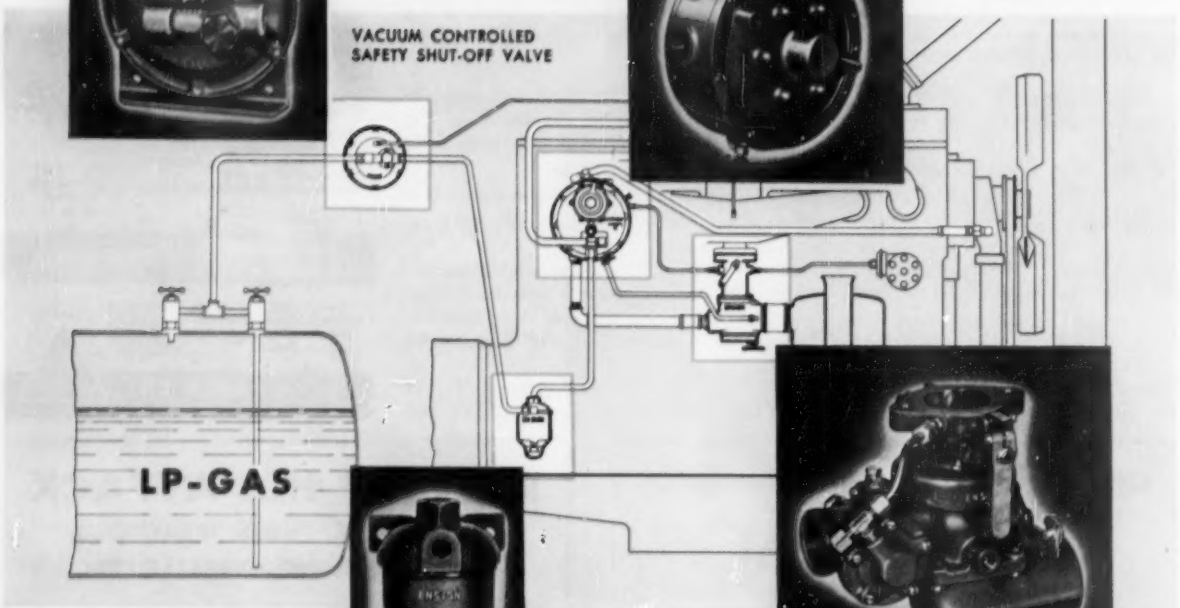

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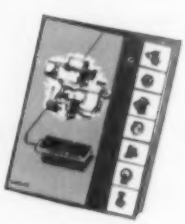

Wyatt Expands Houston And Dallas Plants

Expansion programs now in progress at both plants of Wyatt Metal & Boiler Works will increase producing capacity materially. At Houston the expansion will permit more efficient production of the larger and heavier processing vessels. The fabrication department is being extended 200 ft. and an additional 200 ft. of open craneway space will extend beyond the added shop area.

In the Dallas plant the facilities required for making trays and bubble caps are being extended. Three complete bays will now be used for this type of fabrication, and each of these bays is being lengthened.

Norton Appointed N. Y. Manager for Dean Brothers

Robert D. Norton has been appointed New York manager of industrial sales for Dean Brothers Pumps, Inc., Indianapolis, according to R. C. Bierck, general sales manager. Prior to joining Dean Brothers, Norton was branch manager for 5 years of a large pump and industrial-supply distributor at Charleston, W. Va., selling to chemical manufacturers and coal producers.

NBT Elects Lambert Ass't. Vice President, Oil Loans

J. G. LAMBERT

Joseph G. Lambert, Tulsa petroleum engineer, was elected assistant vice president of National Bank of Tulsa at the monthly board of directors meeting. A. E. Bradshaw, NBT president, said Lambert would be assigned to the oil-loan department.

In 1948 Lambert joined Stanolind Oil & Gas Co. as a petroleum engineer in the Wyoming division. He worked 3 years as an evaluation engineer in the petroleum department for Chase National Bank of New York City. Lambert joined Earlougher Engineering Co. as an engineer in 1953. He joined the NBT staff in March 1953.

Williams Heads Instrument Division, Perkin-Elmer

Dr. Van Zandt Williams, a vice president of The Perkin-Elmer Corp., has been named general manager of

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the company's newly formed instrument division, it has been announced by Richard S. Perkin, president and chairman of the board. The new division will be responsible for the development, production, and sale of the company's line of analytical instruments.

Williams joined the company in 1948 as director of instrument development. In 1951 he was elected a vice president and director of the corporation. Prior to his new appointment, he was responsible for the company's sales and research.

Nye Heads Petroleum Dept. of First City Natl.

G. L. NYE

Consolidation of the First and City National Banks into First City National Bank of Houston has created one of the Southwest's most experienced staffs for oil and gas financing. The oil and gas division is headed by George L. Nye, professional engineer and geologist. Vice presidents in the division are A. G. Gueymard and Ed M. Reed. Assistant vice presidents are W. E. Bridgforth and Pete W. Cawthon, Jr.

Nye organized City National's oil and gas department in 1954 after holding executive engineering positions with Tide Water Associated Oil Co.

Reed joined First National in 1940 as vice president in charge of the oil and gas department, after work as an independent oil operator and an engineer with Gulf Refining Co., Shell Oil Co., and Rycade Oil Corp. Gueymard joined City National in 1947 after engineering work with Tide Water Associated Oil Co. and Stanolind Oil Co.

GUEYMARD

E. M. REED

He was elected a vice president of City National in 1953.

Until joining City National in 1950, Cawthon was with Phillips Petroleum Co. He was promoted to assistant vice president in January 1956. Bridgforth joined First National Bank in 1923 as a bank messenger and was successively promoted. He was elected assistant vice president in 1951.

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Williamson Representatives Attend Refresher Course

A group of T. D. Williamson, Inc., representatives inspect the latest model of WmSon-Hillco tapping machines while attending a refresher course held at the Tulsa offices and factory periodically for Williamson representatives of the United States and other countries.

Standing: Tod Pazdral, Jim Ford, and Dick McHenry, all of Tod Pazdral Pipeline Specialties, Houston; Don Corp, factory engineer; Ken Cusick, James S. Kone & Co., Amarillo; Fred Crandall, research engineer; and T. D. Williamson, president.

Kneeling: Jack Stout, Canadian Equipment Sales & Service Co., Ltd., Edmonton, Alta.; Jack Duke and Jack Pelkey, both of Tod Pazdral, Houston.

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Bethlehem Supply Ends Two-Meeting Sales Assembly

Group of Bethlehem Supply Co. representatives are shown in the new conference room at the Tulsa plant. I. C. Smith, general manager of sales, who was in charge of the two sales meetings held March 26 and 27 and April 2 and 3, is shown standing in the back of the room at the extreme left.

Bethlehem Supply Co. held the second of its two-meeting series on April 2 and 3 at its Tulsa plant. The meetings were held primarily for discussion on the Bethlehem line of general-service pumps, including the engineering design and their field application. The meetings also covered all other Bethlehem-manufactured products.

The out-of-town personnel attending these two meetings totaled about 113. Included were district managers, machinery sales representatives, and store managers from 71 Bethlehem stores and offices.

The sales meetings were under the supervision of I. C. Smith, general manager of sales. Those company representatives who attended the final meeting were: W. B. Page, R. M. Cox, R. A. Blair, T. W. Teague, C. E. Medley, L. T. Matuszewski, E. M. Bragg, Jr., C. A. Pigg, J. D. Wooten, R. V. Bradley, E. S. Edwards, C. N. Gage, Jr. R. B. Dearing, H. M. Braymer, J. S. Tayrien, G. R. Cannon, Edgar Wood, J. R. Norris, D. A. McCoy, H. B. Karstetter, I. E. Hood, H. E. Redden, D. O. Thomas, A. J. Chauvin, Jr., H. L. Hawkinson, Jr., W. J. Brady, J. B. Ellzey, E. R. Phillips, E. S. Lewis, G. B. Sager, Jack Graves, F. R. House, W. R. Hempkins, H. F. Ninman, D. G. Collins, J. A. Buland, U. C. Blankenship, J. E. Briggs, D. G. Rhoads.

R. D. Christopherson, O. D. Dickey, O. N. Wilson, J. D. Pritchett, R. C. McAnally, R. E. Hudson, J. M. Finger, J. D. Fenner, Jr., A. L. Moody, H. L. Daniels, G. M. Chaddick, Nealy Nevils, Jr., Clyde Ricks, R. R. Buckle, B. E. Schmidt, V. H. Prange, Jr., and K. G. Wagner.

J&L Steel Promotes Somerville and Latimer

Peter P. Somerville, formerly plant manager of Jones & Laughlin Steel Corp.'s Wire Rope Division, at Muncy, Pa., has been appointed general manager and Ivan N. Latimer, field supervisor of the division, has been named assistant general manager. All operations of the Wire Rope Division will be headquartered at Muncy.

Somerville joined J&L in 1938 as superintendent of the Muncy plant. Prior to joining J&L, Somerville was employed by Williamsport Wire Rope Co. and by Bethlehem Steel Corp.

Latimer joined J&L in 1929 in the accounting department. He became chief clerk, Wire Rope products, in 1941. Latimer was promoted to field supervisor in 1952.

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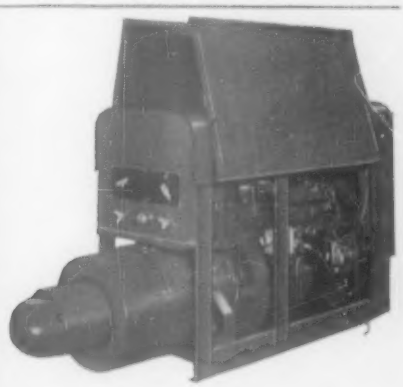

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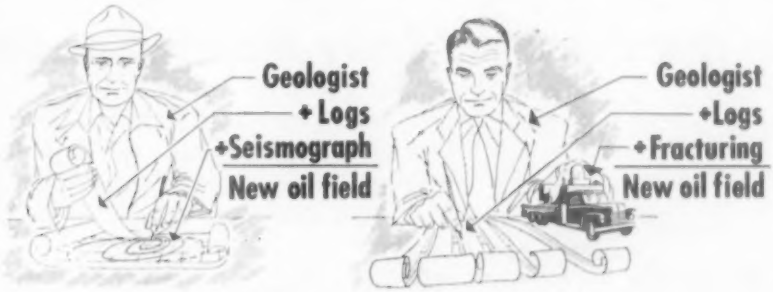


There's a New Force at Work In Exploration . . . It's *Fracturing*

by Norman S. Morrisey

FRACTURING has injected a new line of thinking into the exploration picture. During 1930-1950, the seismic map determined whether a wildcat was staked. Today in many instances the deciding factor is a show of oil logged in formerly uneconomic sand. The zone in all probability was not even tested when the well was originally drilled. New oil companies are offsetting the dry hole and getting flowing wells after a fracture treatment; or cleaning out the dry hole, fracturing the sand, and completing the duster.

Fracturing has made all this possible. Marginal wells or dry holes are now paying propositions. Geophysics, although still a highly successful method of exploring, has taken a back seat in some areas.

But what effect has fracturing had on exploration? A study of Oklahoma's 1955 discovery record may answer this question. In 1955 there were 207 successful exploratory holes completed in the Sooner State. Sixty per cent of these discoveries were fractured prior to completion, and an additional 10 per cent were acidized. Thus, it was necessary to use some form of artificial stimulation on 70 per cent of Oklahoma's discovery wells in 1955.

In many areas, the shooting step is eliminated or the seismic is used to map the sand body rather than a structure. Geologists are combing over old drillers' logs, sample logs, and electric logs. The object is to find a sand that has a show of oil, or that appeared to be oil-bearing on the electric log. The logs seldom cost over $1.50 each. And you can buy 400 to 500 logs for the price of 1 day's shooting. It's a cheap method of exploring, but completion costs and exploitation are more expensive because of fracturing.

What is a drillable prospect? . . . That's a good question with many possible answers. Some companies use a rule of thumb "at least 30 ft. of pay at 3,000-3,500 ft. Anything less than that is too risky and will not pay out." Drilling to these sands, at least in Oklahoma, is relatively inexpensive and operators get a look at the sand for $10,000-$15,000, depending upon local conditions. If the sand is present, the usual procedure is to run casing and then fracture the sand.

The fairly rapid payout, the shallow drilling depths, and the cost of a completed well make fracturing attractive to small operators. But many of Oklahoma's Pennsylvanian sands have rather low recoverable reserves by primary methods, ranging from 100 to 200 bbl. of oil per acre-foot of sand. Some of the sands are undoubtedly uneconomic on 10-acre spacing, but by developing the fields on 20-acre spacing or even on 40-acre units, the sand can be a money-making proposition.

Exploration costs . . . Stratigraphic plays are relatively inexpensive. And in the older areas where well control is plentiful, the risk is relatively low. A completed 3,500-ft. field well costs about $35,000 in Oklahoma and the payout period may be under 2 years. Acreage is fairly cheap in the older areas of Oklahoma, and the same is probably true in other parts of the country.

Economics . . . But is this type of exploration profitable? Based on national averages for successful wildcats, finding costs* are on the order of $0.90 per barrel for "strat-trap" exploration in northern Oklahoma if the new field is developed on 20-acre spacing (Table 1). This compares quite favorably with present-day finding costs of $1.50 to $2.00 per barrel. On 10-acre spacing, finding costs for this type of oil trap are $1.41 per barrel.

Actually, the cost of fracturing is nominal when compared to the total well cost, probably upping the cost of a completed well 10-15 per cent maximum. But the fracture treatment will increase the well's initial potential 10 or 20 times or even more. The oil is recovered more quickly, and fracturing will even increase the ultimate recovery from the well, according to some engineers.

Will fracturing continue to influence exploration thinking? Apparently so, for service companies estimate that they have treated about 120,000 wells since the method was first discovered. This represents between 20 and 25 per cent of the total producing oil wells in the United States today. And the number of treatments continues to increase each month.

*In this article, finding costs include the costs of exploration, leasing, and drilling of both wildcat and field wells.

ESTIMATED COST OF "STRAT-TRAP" EXPLORATION IN NORTHERN OKLAHOMA

	Cost per prospect	Total
Exploration work on 16 prospects	$500.00	$8,000
Leasing at $10.00 per acre (640 acres per prospect)	$6,400.00	$102,400
Drilling costs on sixteen 3,500-ft. wildcats	$15,000.00	$240,000
Completion costs on two wildcats,* including fracturing	$20,000.00	$40,000
Estimated reserves (20 ft. of sand, 125 bbl. per acre-foot, 320 acres productive per field), bbl.	800,000	1,600,000
Number of development wells on 20-acre spacing	15	30
Cost of development drilling and completion at $35,000 per field well	$525,000.00	$1,050,000
Total cost of exploration and development		$1,440,400
Estimated cost per barrel of new oil (20-acre spacing)		$0.90
Estimated cost per barrel of new oil (10-acre spacing)		$1.41
Present-day finding costs per barrel†		$1.50 to $2.00

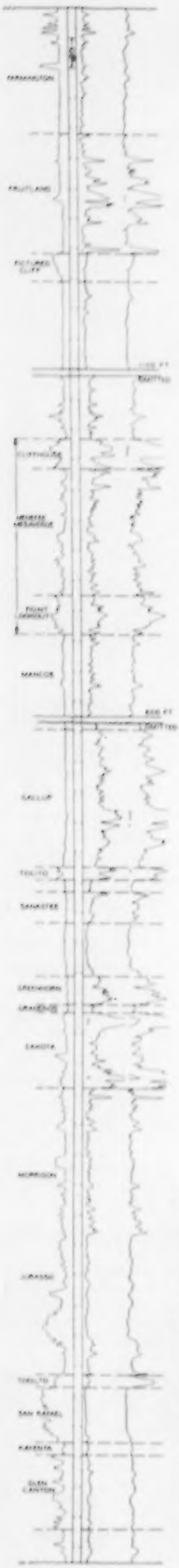
*Industry figures show that only one in eight new-field wildcats is successful. †See The Oil and Gas Journal, March 19, 1956, page 128.

Where Production Comes From . . .

in four important Rocky Mountain basins

Here are type electric logs from San Juan, Williston, Big Horn, and Denver-Julesburg basins, with photos of typical cores. Interest in this quartet of basins is high because of the promise they hold for major fields

by John C. McCaslin
District Editor



Type electric log of San Juan basin, the biggest gas-producing area in the Rockies. This log and those following are courtesy Schlumberger Well Surveying Corp. The geological information on the logs was compiled by the Schlumberger Rocky Mountain area staff. Large-scale reproductions of the logs of these basins and other important Rocky Mountain producing areas may be obtained from Petroleum Information, Denver.

San Juan

THE San Juan basin of northwestern New Mexico and southeastern Colorado is the largest gas-producing area in the Rocky Mountains. The ultimate in productive possibilities has by no means been reached. As a result of new pipeline outlets to Pacific Northwest, exploration and development will increase in the near future. More oil and gas can be expected, particularly in the deeper horizons below the Upper Cretaceous.

Geologic Sketch

The San Juan basin is both a structural and topographical depression which in general cross-section approximates the shape of a broad, shallow bowl. The basin is a structural embayment into the Rocky Mountains. Strata in the center of the basin are nearly flat lying, forming monoclines with very slight dips toward the center of the basin.

Pay Zones

Sediments in the San Juan basin range in age from Tertiary through Cambrian. Plugs, dikes, and lava flows are common, forming prominent surface features in many sections of the basin. Most of the gas proved and indicated for the basin comes from Cretaceous and Pennsylvanian rocks. Oil production is restricted to the Cretaceous. The big gas fields in the basin's center produce from the Pictured Cliffs sand and the Mesaverde group of Cretaceous age. One of the pays of future promise in the basin is the Cretaceous-Dakota. Pennsylvania gas has been found in the northwest part of the basin in the Hermosa-Paradox at Barker Creek dome, Ute Dome, and North Chimney Rock. Doswell field in the center of the basin produces oil from the Tocito-Cretaceous. Oil fields on the northeast, west, and south sides of the basin produce from Mesaverde group sands, Mancos shale, and the Dakota.

Significant Fields

Oil production in the San Juan basin totals about 1,034,845 bbl. per year. Total gas production is about 150,000,000 M.c.f. yearly. The biggest oil producer in the basin is Doswell field, accounting for more than half the total area production. The pay at Doswell is the Tocito sand, a strat trap. The only other field in the basin that produces more than 100,000 bbl. per year is Hospah-Dakota field.

The most important fields in the basin are: Barker Creek (Dakota gas), North Chimney Rock (Pennsylvania gas), the Central Basin fields (Pictured Cliffs and Mesaverde sands gas), Ignacio (Fruitland, Pictured Cliffs gas).

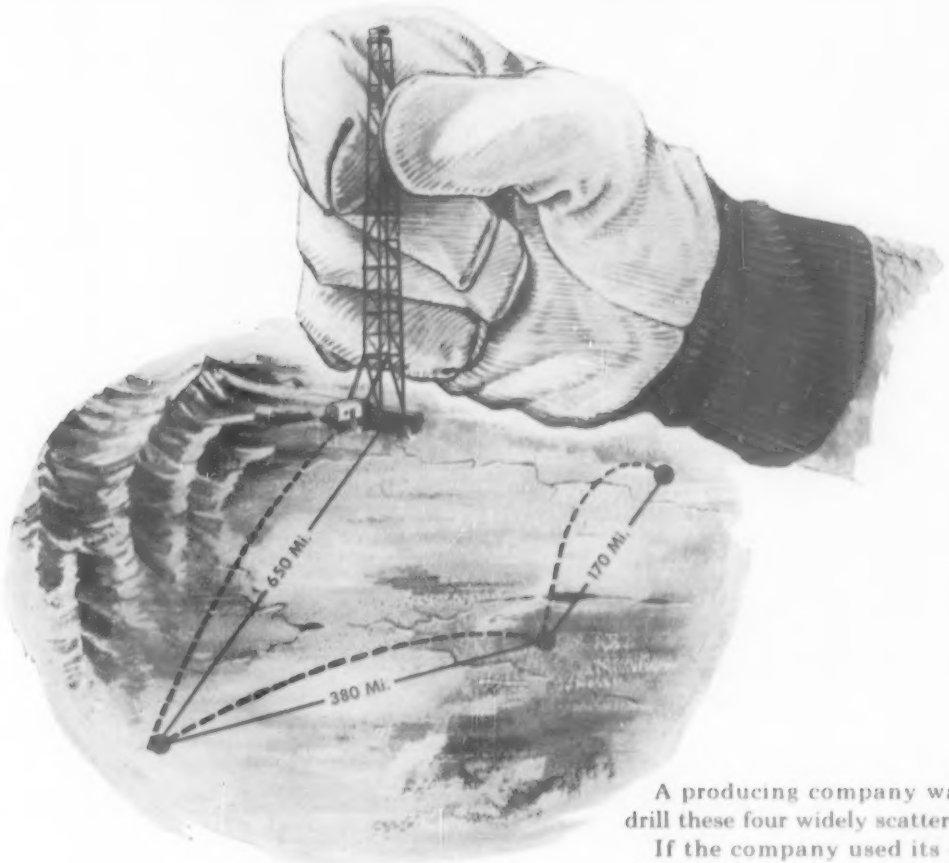
Williston

The Williston basin is the newest producing basin in the Rocky Mountain province. It is also the biggest basin in area in the entire region, covering 120,000 sq. miles of North and South Dakota, Montana, Saskatchewan, and Manitoba. Oil was not discovered in the Williston basin until early 1951, but since that time many prolific producing areas have been established in Montana, North Dakota, and Canada. For the past 2 years activity slowed down in the Williston region. However, 1955 discoveries in remote sections of the basin plus new strikes in the known producing areas have sparked new interest in the unknown potentialities of this huge area.

Geologic Sketch

The Williston basin is located entirely in the Great Plains physiographic province, but is considered a Rocky Mountain unit. The basin is of sedimentary origin, having no obvious limits that characterize all other Rocky Mountain basins, except for the Black Hills and Bowdoin Dome. Though there are slight surface expressions of

Suppose you owned a drilling rig...



COULD YOU AFFORD THESE MOVES?

A producing company wanted to drill these four widely scattered wells.

If the company used its own rig, the moving costs alone would be $48,216.

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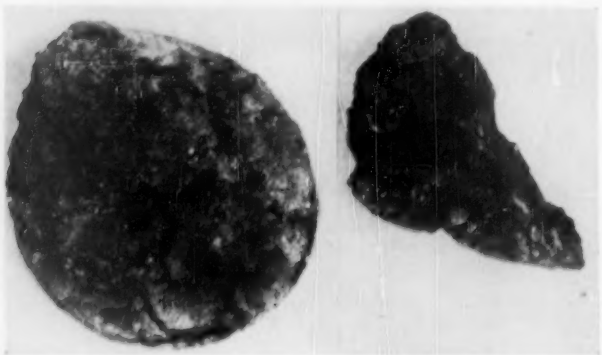
MADISON GROUP (Charles and Mission Canyon-Mississippian). From Nesson anticline well, North Dakota. The Madison group formations are the chief producing zones in the Williston basin. Major producing areas include Beaver Lodge, Tioga, and other Nesson anticline fields. The Mission Canyon produces in southeastern Saskatchewan and northeast North Dakota along the truncated wedge edge. (Staff photo.)



Red River (Ordovician). Core from Ohio Oil Co. 1 Government, 4-1s-62e, Carter County's Repeat area, Montana. Depth 8,600 ft. Discovery well flowed 490 bbl. of oil in 11½ hours on 20/64-in. choke. The Red River is the number two pay zone in the Williston basin, producing chiefly on the Cedar Creek anticline in eastern Montana. (Photo courtesy Northwest Geological Service).

Rocky Mountain Basins

deep-seated structure in the basin, only three are of regional significance: the Nesson, Poplar, and Cedar Creek anticlines.

Pay Zones

To date commercial production in the Williston basin has been proved in the Cretaceous, Jurassic, Triassic, Pennsylvanian, Mississippian, Devonian, Silurian, and Ordovician. The most prolific pay zones in the basin are the Mississippian Madison Group and the Red River lime of Ordovician age. Most of the basin's production is restricted to the three mentioned anticlines and to the southeastern Saskatchewan and southwestern Manitoba regions. Current exploration promises new producing areas in the areas between the Nesson anticline and the northeastern rim of the basin.

Significant Fields

Beaver Lodge and Tioga remain at the top of big producers in the North Dakota portion of the basin, both producing from the Mission Canyon-Mississippian Madison limestone. Poplar field in eastern Montana is that area's big producer, getting its oil from the Mission Canyon. There is a long list of Ordovician-Red River fields up and down the Cedar Creek anticline of Montana. Significant Mission Canyon production in the Canadian protion of the basin is located in Saskatchewan and Manitoba.

Type electric log of Williston basin, the largest basin in the Rockies, and the newest to the production list.

Big Horn

More than half of the oil produced in Wyoming comes from Big Horn basin fields. About 30 per cent of the oil produced in the entire Rocky Mountain province is Big Horn basin production.

Geologic Sketch

The Big Horn basin is a well-defined topographic and structural depression in northwestern Wyoming. There are prominent lines of surface-expressed folding within the basin which include well-defined anticlines roughly paralleling the bordering mountains. With few exceptions the fields of the basin are restricted to the basin edges on these series of satellite anticlines.

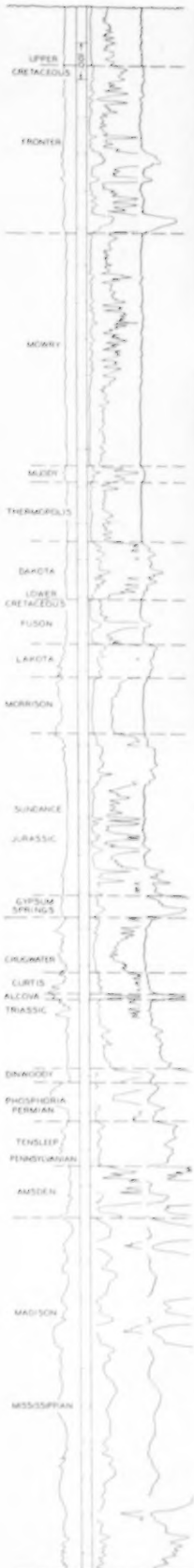
Pay Zones

Sediments in the basin range in age from Recent through Cambrian. To

Phosphoria or Embar (Permian), Slick Creek field, Washakie County, Wyoming. The Phosphoria or Embar is a big producer in the Big Horn basin, chiefly at Worland and Manderson fields. (Photos of all three Big Horn basin cores courtesy Core Laboratories, Inc.).

Tensleep (Pennsylvanian), Bonanza anticline, 2,755 ft. (Bonanza field, Big Horn County, Wyoming). This formation is a thick sand, shale, and limestone sequence that is distributed throughout the Big Horn basin. It is one of the most important pay zones in the region, producing at such fields as Bonanza, Elk Basin, Garland, and others.

Madison (Mississippian). Nowood Anticline, 4,058 ft. Bonanza field, Big Horn County, Wyoming. The Madison group is a widespread oil reservoir throughout much of the northern part of the Rocky Mountain province. The Madison is one of the top three producing formations of the Big Horn basin.



Type electric log of Big Horn basin, the biggest producing area in the Rockies.

date production has been found in the Cretaceous (Frontier, Mowry, Muddy, Dakota, and Lakota), Triassic (Morrison and Sundance), Jurassic (Chugwater), Permian (Phosphoria and Embar), Pennsylvanian (Tensleep), and the Mississippian Madison and Amsden. There have been few tests of pre-Cretaceous rocks in the basin center and of pre-Mississippian rocks anywhere in the basin.

Significant Fields

Although the Big Horn is a relatively small basin in area, it is the biggest producer in the Rocky Mountains. The three main pays are: Phosphoria (Permian), Tensleep (Pennsylvanian), and Madison (Mississippian). Oil from these pays is black with varying percentages of sulfur. The sweet green oil of the basin comes from Cretaceous sands such as the Frontier and Muddy.

The most important fields in the basin are: Elk Basin (produces from Frontier, Embar, Tensleep, and Madison); Frannie (produces from Tensleep and Madison); Garland (produces from Embar, Tensleep, and Madison); Byron (Embar and Tensleep); Worland (Embar); and Bonanza (220-ft.-thick section of Tensleep).

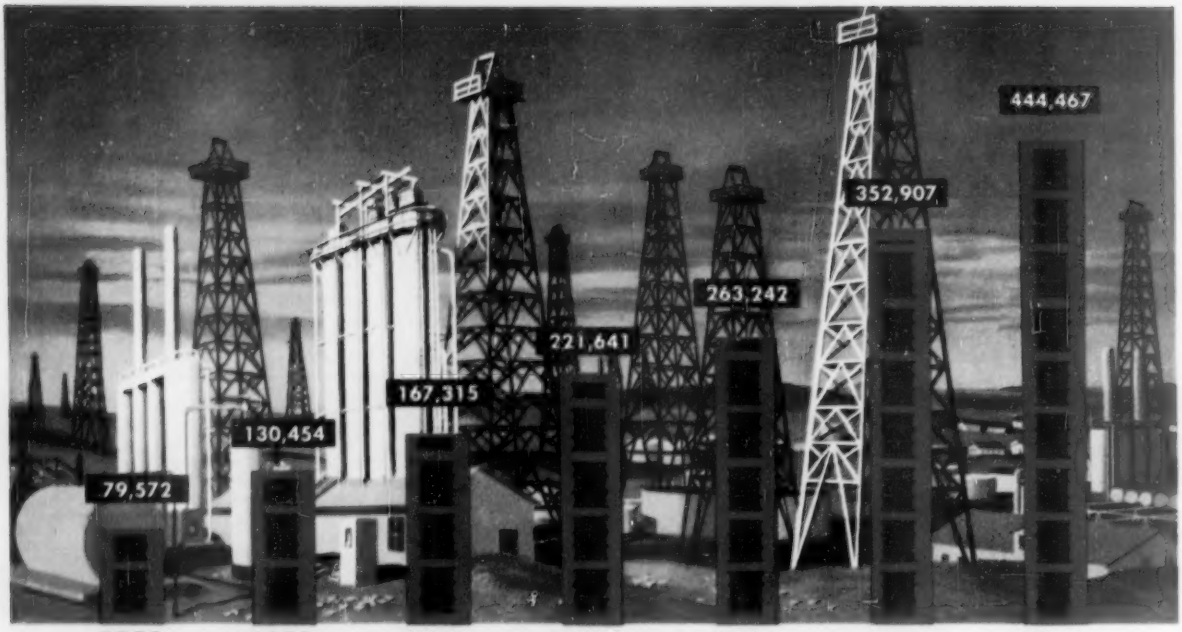
Denver-Julesburg

The Denver-Julesburg basin of northeastern Colorado, southeastern Wyoming, and western Nebraska is consistently the leader in over-all drilling activity in the Rocky Mountain province. The lure of moderate depths, comparatively low drilling costs, and a favorable land-leasing situation, plus new outlets have kept drilling in this basin at a fast clip for the past several years. Oil was first discovered in the Denver-Julesburg basin in 1862, but it was not until 1949 until the boom got under way after Ohio Oil Co.'s Cheyenne County, Nebraska, discovery.

Geologic Sketch

The Denver-Julesburg basin, though a Rocky Mountain basin by virtue of its location next to the Front Range, is a part of the Great Plains physiographic province like the Williston. The basin is asymmetric with a very gentle east flank and a very steep west flank. The axis of this sedimentary unit passes under Denver and Cheyenne in a north-south direction.

Type electric log of the Denver-Julesburg basin, the leading development and exploratory area in the Rockies. Current activity is highest in the Nebraska portion.



(Approximate production figures in barrels per day)

Canadian Oil Barrels Ahead!

Canada's 1955 oil production was up a remarkable 34% over 1954, and for the first month of 1956 production was running 26% over the average figure for 1955. A big oil find has recently been reported north of the famous Peace River district and it has precipitated the "biggest oil rush" in the history of Northern Alberta.

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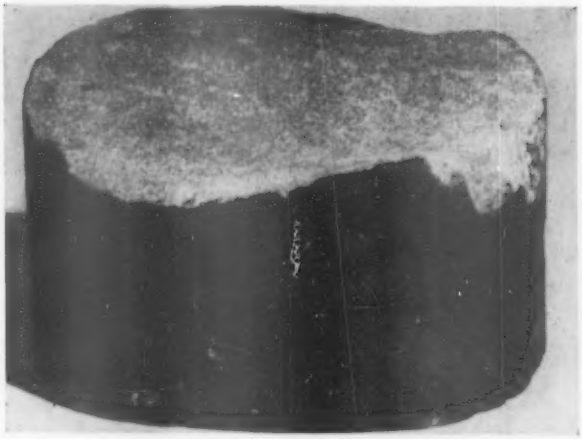
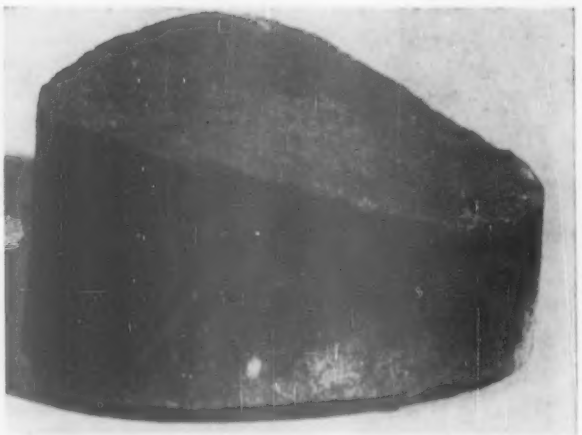
Rocky Mountain Basins



"D" sand (Dakota) Upper Cretaceous. The "D" sand produces in scattered areas of eastern Colorado and western Nebraska. It ranks second in importance to the "J" sand (Dakota). (Photo courtesy Core Laboratories, Inc.)



"J" sand (Dakota), Upper Cretaceous. The "J" sand is the chief reservoir sand in the Denver-Julesburg basin; production is controlled by stratigraphy to a very large extent. (Photo courtesy Core Laboratories, Inc.)

Pay Zones

The major part of the basin's production is from rocks of Cretaceous age, chiefly the Dakota group sands. There is some production from the younger Greenhorn and two fields on the west side of the basin produce from Permian-Lyons sand. Production appears to be along definite trends and is controlled by both structure and changes in stratigraphy.

Significant Fields

Exploratory and development drilling in the Denver-Julesburg basin in the past 2 years has given rise to fields of importance in Colorado and Nebraska. The most significant relatively new producing area in Colorado is Adena field with a daily production of 15,276 bbl. and is second only to Rangely in Colorado production. Harrisburg field remains Nebraska's big producer. New entries into the Nebraska production race are Doran and Potter fields.

EXPLORATION HIGHLIGHTS

WESTERN CANADA

BRITISH COLUMBIA

Phillips Wildcat Finds Gas in Four Formations

A wildcat in northeastern British Columbia, being drilled by Phillips Petroleum Co., reported finding gas in four formations during drill-stem test operations. The well, according to reports, also recovered 75-150 bbl. of condensate per day from the Mississippian as well as an 8-12,000 M.c.f. per day gas flow. That flow and condensate recovery was recorded during production tests.

The well, 1 Kobes, located at 56 degrees 29 minutes North Latitude and 122 degrees 02 seconds West Longitude, is a wholly-owned Phillips venture which lies 50 miles northwest of Fort Staint John and 28 miles northwest of gas completions in that area.

Complete details on the new discovery, or previous discovery tests run at the well, have not been announced by the operator, but it has been reported that the Cadomin, Permo-Penn and Triassic, as well as the Mississippian, have all given up gas in commercial quantities. Production tests continue at the wellsite.

ALBERTA

Field Conference Announced By Alberta Society Group

The Alberta Society of Petroleum Geologists is planning to hold their sixth annual field conference on August 23-25, or on Thursday through Saturday of that week. Registration will begin on the evening of Wednesday, August 22. The area chosen for this conference is between Calgary and Banff, and it will center in the Canmore-Kananaskis region.

Papers will be presented in Calgary on Thursday and an evening session will be used for discussion of papers heard earlier.

Cardium Recovery Reported At Leslieville Area Test

Mobil Oil of Canada, Ltd., recorded a pipe recovery of 175 ft. of 41°-gravity oil and 105 ft. of mud on a drill-stem test of the Cardium sand at its 16-12 Leafland wildcat in the Leslieville area of central-west Alberta.

This new Cardium strike is 5 miles northwest of Leslieville town, 3½ miles north of the Leslieville Cardium oil field, and 8½ miles south of the most southerly oil well in Alhambra-Cardium oil field. The 16-12 Leafland, LSD 12, 16-40-5w5, topped the Cardium sand at about 6,010 ft. The drill-stem test covered the interval at 6,000-20 ft. The well also flowed gas at 108 M.c.f. per day.

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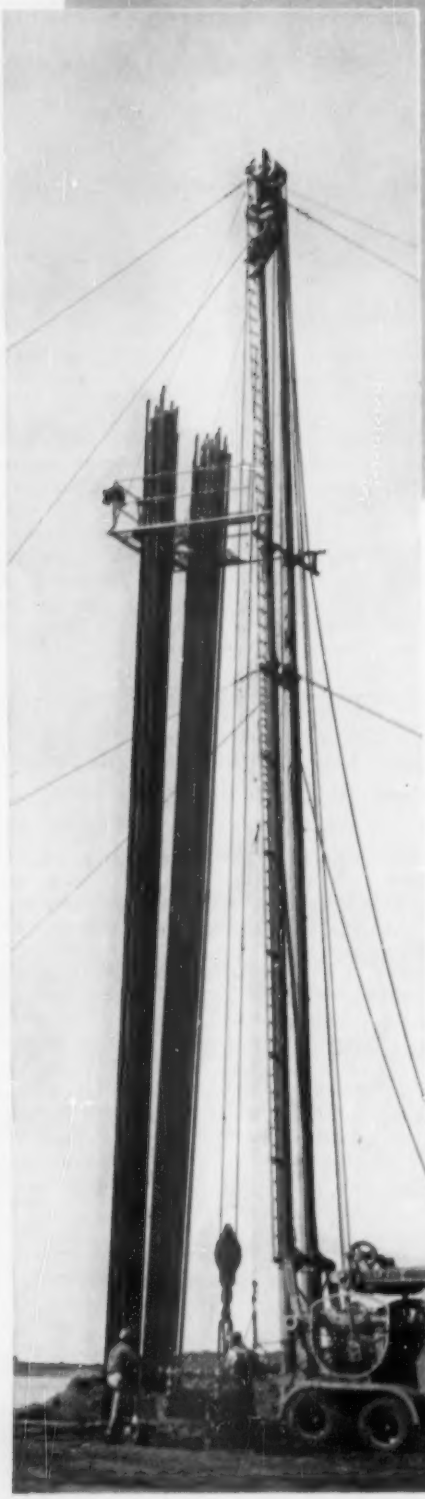

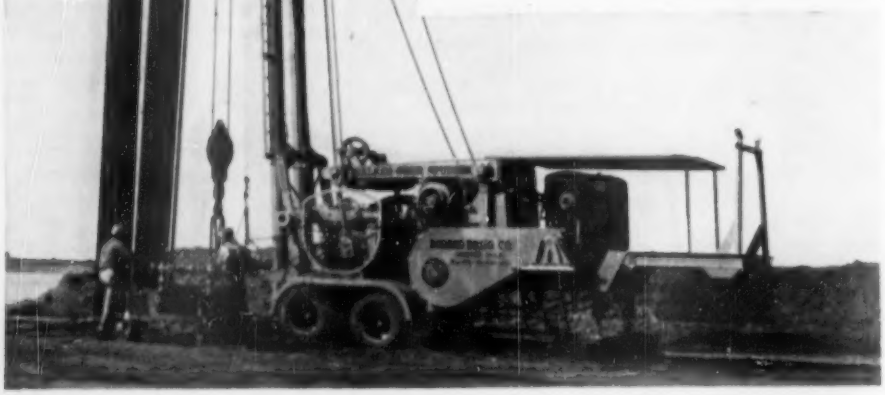

Pictured here on its first job is the new C-34 purchased by Bodard Drilling Company, Shawnee, Oklahoma. Crew and rig "got acquainted" by pulling 4800 feet of tubing in one hour and 20 minutes, including a few minutes lost for minor adjustments in the new rig.

Every pulling and drilling job in this secondary recovery operation was handled by this one machine—with speed and efficiency not offered by any other type or make of equipment. The C-34 is one of 9 models in the Walker-Neer "C" Series —see description on opposite page.

# of Tubing in 80 Minutes

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- **All drums, masthead sheaves, clutches, and adaptors are mounted on sealed roller and ball bearings which reduce maintenance to an absolute minimum.**
- **Each drum has double, self-energizing, self-equalizing brakes—your assurance of positive, balanced, trouble-free braking.**
- **You obtain a POWERFUL, BEAM-TYPE SPUDDING ACTION. The long spudding beams are equipped with Walker-Neer's famous "Tor-Shock" (Rubber Torsion) Shock Absorber which snaps the tools and cushions the rig against jar.**
- **All controls are counter-balanced to respond to fingertip pressure, and every operation is controlled from the operator's platform.**
- **Traveling spudding sheaves and heel sheaves assure automatic spooling and reduce wear on wire line.**
- **All drives have disc-type friction clutches. The sand reel on all models is a full floating drum.**
- **All models conform to legal weight requirements, and all except the C-37 and C-34 are 8 feet or less in width.**
- **All chains, bearings, clutches, and sprockets are standard sizes and makes—replacement parts can be obtained promptly from Walker-Neer or from any machinery dealer.**
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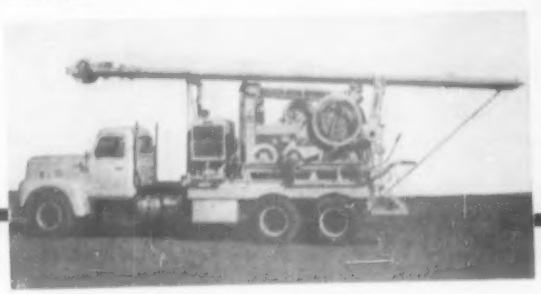
3-DRUM MODELS	CAPACITY	2-DRUM MODELS	CAPACITY
C-37	8,000′	C-27	7,000′
C-34	6,000′	C-25	5,000′
C-33	4,000′	C-23	3,000′
C-32	3,000′	C-22	2,000′
C-31	2,000′		

Pictured below: Model C-32. All models except C-37 and C-34 can be truck mounted, with separate engine or powered by truck engine. All models can be trailer or skid mounted.



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UTAH'S SUCCESS RATIO ranks second among its Rocky Mountain drilling neighbors. Drilling is heaviest in Grand County on the Colorado Plateau, but two excellent discoveries in the Paradox basin in recent weeks have put new life into this inviting oil province. Map after Petroleum Information, Denver.

Utah goes into No. 2 spot in Rockies as . . .

Paradox Basin Continues Payoff

by John C. McCaslin

THE stepped-up gas search on the Colorado Plateau of eastern Utah and recent oil discoveries in the Paradox basin have pushed this Rocky Mountain state into second place on the exploratory success scale.

Development of new gas fields in Grand County on the east side of the state and an upsurge in exploratory interest in the Paradox region have rekindled smoldering drilling fires in the Four Corners province.

Grand County gas hunt . . . The drilling spree that began 2 years ago in eastern Utah's Grand County is back in full swing after rather severe winter weather on the west side of the Rockies.

Nine active rigs promise that this Colorado Plateau area will once again lead the state's drilling program this year. This prolific county saw more than 40 wells completed last year. This year, 6 wildcats have been completed and 20 wells are currently looking for gas and oil.

. . . Regional scene. Grand County lies west on the vast Colorado Plateau. The northern part of the area is in the southern portion of the Uinta basin. The southern portion lies in the northern extremity of the Paradox basin.

. . . Drilling activity. Center of the county's current activity is the Bax-X unit. Three wells are testing gas recoveries. There have been three excellent gas-well completions in the unit this year on the Utah side of the fence. Drilling on the Colorado side of the field is quiet.

The Seiber Nose discovery made by Carter Oil Co. last year sparked the current drilling boom in this region. Last autumn, Sinclair Oil & Gas Co. established gas production at San Arroyo. Later, Carter opened Morrison oil production at 1 Larson-State in C NE NW 2-20s-24e. This well flowed 126 bbl. of oil per day from shallow Morrison perforations near the 1,500-ft. mark. A Dakota gas discovery in C NE NE 36-20s-21e, Cabeen 1 State, made 1,500 M.c.f. per day—adding further interest to the area's potentialities. Seiber Nose-E gas field was opened last summer at Smith et al. 1 Government in NE SE NE 31-19s-24e. The Dakota well flowed 1,470 M.c.f. per day. Location is 5 miles northwest of Seiber Nose field.

The southern half of Grand County saw wildcat action last year. King Oil Co. opened Big Flat field, 10 miles west of the own of Moab. The discovery well pumped 15 bbl. of oil per day from the Leadville-Mississippian, opening first Mississippian production in the Paradox basin.

Another Grand County discovery was made last year at Ute Royalty Corp. 1 Government in NW NW NE 31-18s-25e (7 miles northeast of Seiber Nose field). This discovery well of Westwater Creek field flowed 3,050 M.c.f. of gas per day from the Morrison at 1,066-78 ft.

. . . San Arroyo. The San Arroyo discovery took top exploratory-success honors in Utah last year. Sinclair's 1 Government in NE SE NW 26-16s-25e, flowed 18,500 M.c.f. per day on 1-in. choke from the Entrada-Jurassic. This discovery had the highest initial potential reported to date in this region. Location of San Arroyo field is 3 miles north of Bar-X unit. Another Sinclair well at San Arroyo is near completion as a Dakota gas discovery. It is located 1½ miles northwest of the field discovery well.

Paradox oil discoveries . . . Recent Pennsylvanian oil discoveries in the remote Paradox basin of southeastern Utah have given a much-needed exploratory lift to this highly regarded future oil province of the Rockies.

The latest oil strike that forces a new look at the potentialities of this geologic paradox is Humble Oil & Refining Co.'s Pennsylvanian discovery at 1-B Navajo. It is located on the southeastern edge of the basin in San Juan County, New Mexico. This well flowed more than 20 bbl. of oil per hour on drill-stem tests of the Paradox-Pennsylvanian. The new field-opener is 22 miles east of Arizona's East Boundary Butte gas field, and 25 miles southeast of Desert Creek.

The biggest news in the Paradox region this year was The Texas Co.'s 1 Navajo Pennsylvanian discovery in San Juan County, Utah. That well

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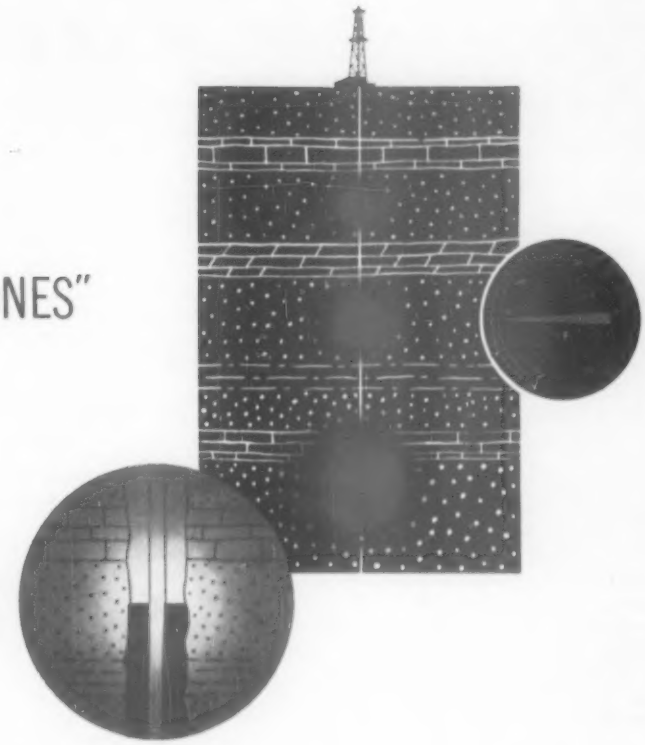

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flowed 1,704 bbl. of oil per day, the biggest gage yet recorded in basin exploration. With these two discoveries behind them, Four Corners operators will begin a drilling campaign in the coming weeks with intense interest.

Open new doors for Utah exploration . . . The Paradox basin is one of the most attractive oil-hunting grounds in the Rocky Mountains. Its depths have scarcely been scratched by the drill. The first commercial oil well in the basin didn't come in until 2 years ago at Desert Creek. That discovery well flowed 248 bbl. of oil per day, giving birth to a whole new exploratory era for Utah.

The Paradox basin is sometimes referred to as the "Salt Basin." It is an evaporate depression, similar to West Texas' famous Permian basin. It is generally believed that reefing of Pennsylvanian formations occurs in the Paradox basin. The Paradox formation itself is 6,000 ft. thick in the basin, and it is only one of many possible pay zones in the region. There is gas production from the Dakota and Ferron of Cretaceous age at the north end of the basin. The Jurassic Morrison and Entrada produce gas in Grand County. The Shinarump and Moenkopi-Triassic produce oil and gas in various Utah fields, and the Mississippian-Leadville produces oil at Big Flat.

The coming of a gas outlet to the region—plus the comparatively shallow and inexpensive drilling costs—make the Grand County and other Colorado Plateau areas highly inviting to gas explorers. These factors, plus the significant oil discoveries in the southeast part of the province, set the stage for an exploratory campaign that will reveal the Paradox basin's true potentialities as a possible major oil province for the nation.

UTAH

Intermountain Association Announces Field Trip Plans

Plans for the Intermountain Association of Petroleum Geologists field conference have been announced. The trip will begin at Price on June 28, ending near Moab on June 30, 1956.

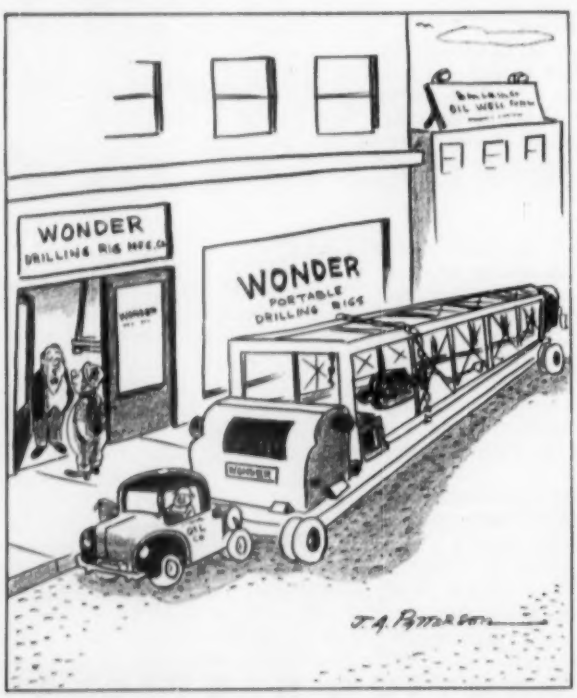
Highlights will include visits to oil, gas, coal, and uranium producing sites, and much of the geologic section from Tertiary through Upper Paleozoic will be seen. Of special interest will be the Book Cliffs, northern Uncompahgre, and Paradox basin areas. Comprehensive road logs will be prepared and a variety of interesting exit routes are afforded.

Lectures and guidebook articles will concern general and economic geology, structure, geomorphology, and archeology. For details contact field trip chairman P. R. Peterson at Box 34, Salt Lake City 10.

Success Hinted at Anneth Area Confirmation

The offset well to The Texas Co.'s big 1,700-bbl. per day Anneth area discovery in San Juan County, Utah, is apparently a commercial producer. Superior Oil Co. reported recovery of 920 ft. of oil on drill-stem test at 5,694-5,771 ft. at its 1 Navajo "A," C SW SE 14-40s-24e. Another test at 5,805-81 ft. got 540 ft. of mud and gas-cut oil, with 30 ft. of oil-cut mud and 90 ft. of oil and gas-cut mud. The apparent discovery got its oil in the Paradox-Pennsylvanian, the same zone as the discovery well.

Successful confirmation of this Anneth area discovery well will put the exploratory heat on in the Paradox basin. Since The Texas Co. completed its 1 Navajo in C NW NE 23-40s-24e,



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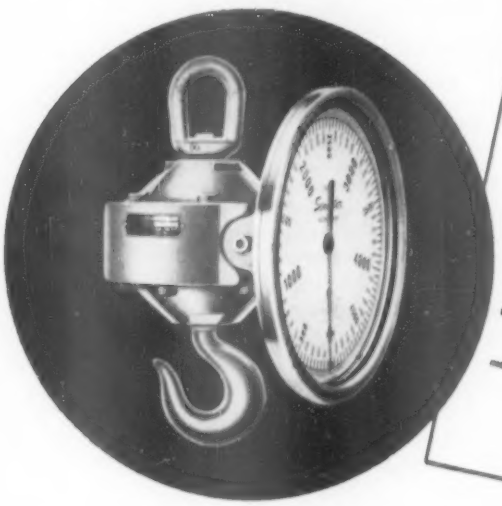

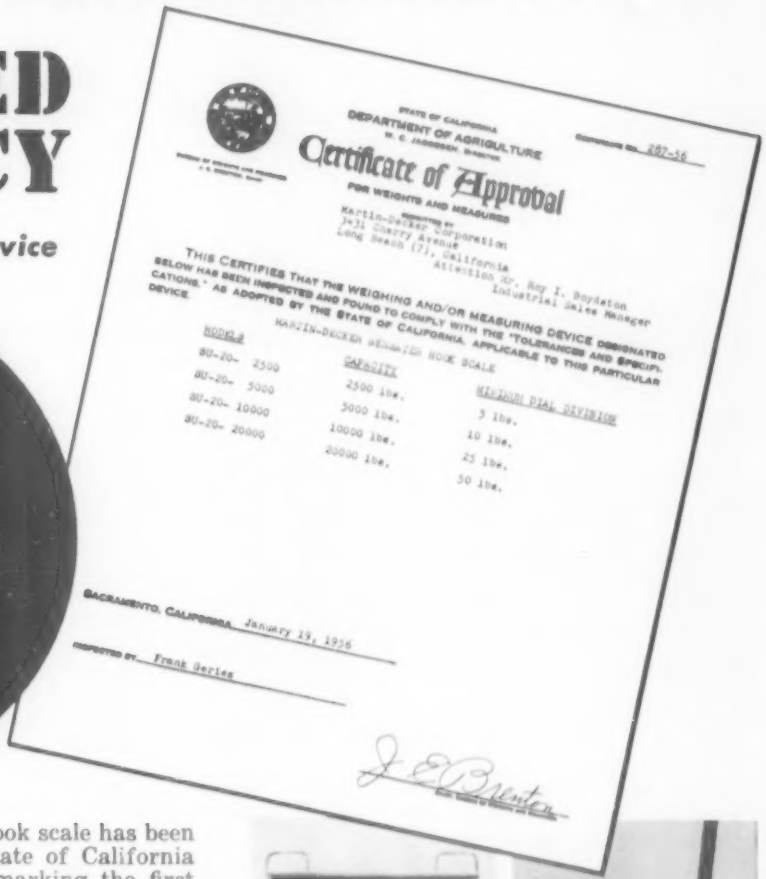

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SU-20- 5000	5000 lbs.	10 lbs.
SU-20- 10000	10000 lbs.	25 lbs.
SU-20- 20000	20000 lbs.	50 lbs.

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Martin-Decker's SU-20 Sensater hook scale has been approved for certification by the State of California Bureau of Weights and Measures, marking the first time that a heavy-duty industrial weight indicator of this kind has ever been accurate enough to be certified *in any state.*

The SU-20 Sensater operates on the same mechanical and hydraulic principles as the E-80 Sensater, the pressure transformer that actuates the Martin-Decker Type "D" or "E" drilling-control instrument. Both the SU-20 and the E-80 use Martin-Decker's patented diaphragm that strokes like a piston — but with no friction whatsoever.

It may not be necessary that an oilwell drilling-control instrument be certified. But, if the time comes that the drilling industry demands proof of the accuracy of the weight indicators it uses, Martin-Decker has the instruments that will pass the test.

DISTRIBUTORS: T. C. Cullen, Bakersfield, Calif., Reed Roller Bit Co., Houston, Texas; Reed Roller Bit Co. of Canada, Ltd., Calgary and Edmonton, Alberta. Martin-Decker weight indicators and Ideal wire line anchors are also sold through The National Supply Co., The National Supply Co. Export Division and other recognized supply houses.

The Martin-Decker Type "D" drilling-control instrument derives its accuracy from the signals transmitted by the supersensitive E-80 Sensater installed as an integral part of the Ideal wire line anchor.

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LABORATORY ANSWERS PERTINENT QUESTIONS ABOUT NON-FLUORESCENT OIL IN EMULSION DRILLING FLUIDS.

No-Glo Oil* Assures Positive Recognition of Oil Zones Under Black Light.

by Doyne L. Wilson
Director of Research
Oil Base, Inc.

Geological interpretations have been the cause of many objections to using emulsion drilling fluids. Contamination of the cores or cuttings have often made it difficult to define with certainty the source of the show under Ultra Violet light.

We feel that you are entitled to all the answers about NO-GLO OIL and its uses, and hope that this information will prove to you that NO-GLO OIL merits a trial on your next job.

QUESTION . . . Is NO-GLO OIL truly non-fluorescent and stable under high temperatures?

ANSWER . . . Yes. It looks just like water under UV or conventional light, and is completely colorless. It is not subject to change under high temperature.

QUESTION . . . Why use a non-fluorescent oil in an emulsion drilling fluid?

ANSWER . . . It assures positive recognition of the oil zones by the fluorescence of their cuttings or core fragments under the UV light.

QUESTION . . . Can NO-GLO OIL be substituted for Diesel oil to achieve the *same* results?

ANSWER . . . NO-GLO OIL can be substituted, volume for volume, for Diesel oil and the resulting drilling fluid will have virtually the *same* physical characteristics and will be maintained in the *same* manner. In areas where the use of commercial emulsifiers are desirable, the same amount of this emulsifier for either oil will produce equivalent mud properties.

QUESTION . . . What are the objections to using Diesel oil or similar cuts?

ANSWER . . Most Diesel, gas, stove or similar oils fluoresce very much like oils from condensate or distillate zones. They impart their fluorescence to the emulsion drilling fluids in which they are used, and hence to the formation. In deep hot holes they develop a fluorescence resembling that of many crudes.

QUESTION . . . Is NO-GLO OIL sufficiently field proven?

ANSWER . . . Yes, with excellent results in Louisiana, East, South and West Texas, Oklahoma, Wyoming, New Mexico, California, Venezuela, Colombia, Peru, and Trinidad.

QUESTION . . . Is there any difference between electrical logs obtained by using NO-GLO OIL as compared to Diesel or crude oil?

ANSWER . . . No. In all of our experience there is no known difference.

QUESTION . . . Are there any special precautions necessary in using non-fluorescent oil after it arrives at the rig site?

ANSWER . . . All tanks and lines for handling the oil should be free from any fluorescent materials. If this is not convenient, the oil may be directly introduced into the mud stream from the delivery truck or drums. Reasonable care should be exercised to minimize contamination by other oils or rig greases. A non-fluorescent thread lubricant is unnecessary if job is of short duration; however, for drilling jobs lasting over ten days, NO-GLO THREAD LUBRICANT should be used.

QUESTION . . . How much does NO-GLO OIL cost?

ANSWER . . . Only slightly more than Diesel oil in most areas, and it is available through distributors in practically every major producing area.

For additional information on the many profitable applications of NO-GLO OIL and NO-GLO THREAD LUBRICANT, contact any Oil Base, Inc. representative.

*NO-GLO OIL is Covered by U.S. and Foreign Patents. Licenses are available.

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six locations have been staked. The Texas Co. is active at five of them. The Superior prospect is the north offset to the Texas discovery and it is the first to reach testing stages. Texas is reported in the Pennsylvanian at two other wells.

Location of this new area of significance for the Four Corners region is 10 miles northeast of Shell Oil Co.'s Desert Creek field. The gage at The Texas Co. discovery well at Anneth was the best yet reported in Paradox basin development.

Down at the other end of the basin in the far northwestern corner of New Mexico, Humble Oil & Refining Co. is swabbing at the 1-B Navajo in C NW SW 29-32n-20w, San Juan County. This well flowed oil at the rate of 20 bbl. per hour on recent tests of the Hermosa - Pennsylvanian. It is located east of the sole producing area in Arizona at East Boundary Butte.

COLORADO

Marmaton Oil Recovered At Baca County Wildcat

Provincial Oil Co. recovered 270 ft. of clean oil on a drill-stem test of the Marmaton - Pennsylvanian lime at 1 State in C NW SE 36-32s-43w, Baca County. The test of this northwestern Hugoton embayment wildcat was made at 4,168-4,241 ft.

Provincial Oil Co. 1 State is an indicated oil discovery for southeastern Colorado's Baca County.

Recovery on the test was 130 ft. of mud-cut oil, 50-60 per cent oil, 180 ft. of muddy oil, 70 per cent oil. Another test at 4,240-91 ft. recovered 15 ft. slightly gas-cut mud. A test taken at 4,331-55 ft. got 1,260 ft. of gas-cut salt water. Drilling is now below 4,355 ft. at the wildcat.

There has been no previous drilling in this area. Nearest production is 8 miles northeast at big Greenwood field in southwestern Kansas. The only oil production in southeastern Colorado is at Bents Fort field on the Las Animas arch, a 1955 discovery of considerable significance.

Frontier Gas Strike Reported in Jackson

Rumors in Denver credited Cabeen Exploration Co. with the first discovery in the North Park basin of north-central Colorado since Battleship field was opened 2 years ago. Cabeen's 1 Blevins in SW SE NW 11-9n-78w, Jackson County, reportedly flowed gas from the

There are rumors of a gas discovery at Cabeen Exploration Co.'s North Park basin wildcat in Jackson County.

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Frontier sand below 1,200 ft. at the rate of several million cubic feet per day. The well reportedly blew out. Location of this "tight" wildcat is 4 miles east of North McCallum field.

Orchard Field Grows With New Locations

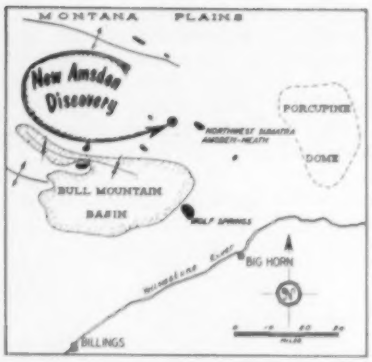
The "J" and "D" sand discoveries in Morgan County's new Orchard field have been completed.

Frank Landauer and Associates 1 "A" Rocchio, NW NW NE 9-4n-60w, was finaled for 60 bbl. of oil per day on pump from the "J" sand. The "D" sand discovery, 1 Buttons in NW NW NW 10-4n-60w, flowed 42 bbl. of oil per hour on 32/64-in. choke. Four new locations were reported as interest in the Colorado portion of the Denver-Julesburg basin quickens.

MONTANA

Amsden Transition Strike Reported in Musselshell

A new spark in the quickening Montana Plains exploratory campaign was reported at R. P. Oliver 3 State, Musselshell County wildcat on the Ivanhoe dome. The newest addition to the growing list of Amsden-Lower Pennsylvanian discoveries on the Central Montana Uplift flowed oil at the estimated rate of 60 bbl. per hour on drill-stem test of the Sumatra zone, a sand in the transition between the Amsden of Lower Pennsylvanian age and the Heath of Upper Mississippian age. The test was run at 3,956-65 ft.



R. P. Oliver 3 State, Ivanhoe dome, Montana discovery in Musselshell County, cored an additional 9 ft. of saturated sand in the Sumatra zone of the Amsden-Heath transition at 3,965-75 ft.

The operator later in the week cored an additional 9 ft. of saturated sand at 3,965-75 ft. Coring continues.

The Amsden formation is coming into its own as one of the important pay zones of the future for the Rocky Mountains. It first entered the significant pay zone list at Northwest Sumatra, 9 miles east of the Oliver discovery. The Amsden-Heath transition sands are erratic and lenticular in this region. One of the most active developments in Montana since Poplar field is under way south of the Oliver discovery at Wolf Springs field in Yellowstone County. The current defined limits of this fast-growing field include an area 6 miles long, northwest-southwest and 3 miles wide.

Nearest production to the new Oliver discovery is ½ mile northeast at Ivanhoe field, a Morrison-Jurassic producer.

NORTHWEST NEW MEXICO

San Juan County Oil Discovery Completed

The Gallup discovery in San Juan County has been completed by British-American Oil Producing Co. The 1 Marya, NW NE NE 1-25n-13w, finaled flowing 595 bbl. of oil per day on ¾-in. choke from perforations in the Gallup at 4,838-56 ft.

This new oil-producing area for the San Juan basin is 3 miles northwest of Bisti field. That Gallup discovery area was opened at El Paso Natural Gas Co.'s 1 Kelly-State in SW NE NE 16-25n-12w, in 1955. The well flowed 180 bbl. of oil per day plus 100 M.c.f. of

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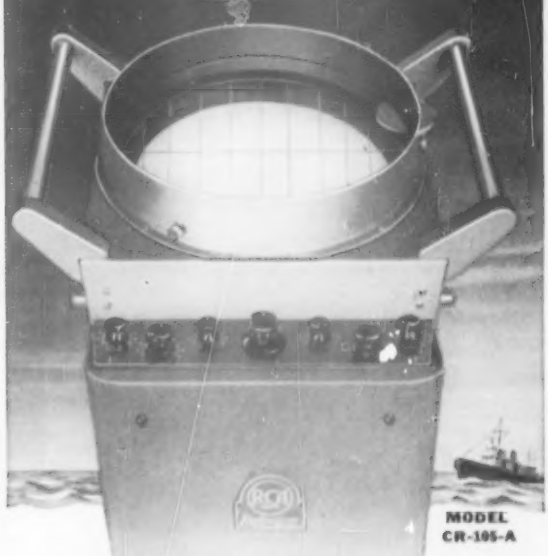

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gas. British-American has two other wells under way in the nev Marya area.

WESTERN NEBRASKA

Morrill County Gets Best Strike Since Olsen

The best discovery in Morrill County since the opening of Olsen field last summer is reported at British-American's 1-D Craig, C NW SW 23-19n-52w. The well pumped 203 bbl. of oil daily from "J" sand perforations at 4,601-05 ft. It is the northernmost oil area in the county and is the fourth field-opener in the past 2 years. Location is 6 miles north of Olsen field.

MID-CONTINENT

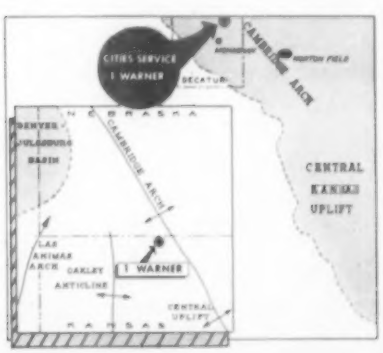
KANSAS

Lansing-Kansas City Oil Recovered at Decatur Well

Cities Service Oil Co. reported a Lansing-Kansas City oil discovery in northwestern Kansas' Decatur County. The 1 Warner, NE NE SW 11-1s-27w, 10 miles northeast of Oberlin, Kans., recovered 2,845 ft. of gas-cut oil on drill-stem test at 3,312-45 ft.

This indicated strike is 2 miles south of the Nebraska line. Nearest production is at Monaghan field, 6 miles south. The 1 Warner discovery prospect is the first strike of consequence in this section of Kansas since the opening of Norton field in Norton County to the east of Decatur. Location of the wildcat is on the west flank of the south end of the Cambridge arch.

Last year exploratory guns were pointed to this region as a result of a Pennsylvanian discovery prospect in Hitchcock County, Nebraska. Months of testing failed to make a producer out of the well, however. Norton field



A Lansing-Kansas City Pennsylvanian discovery was reported at Cities Service Oil Co.'s 1 Warner, a wildcat on the southwestern flank of the Cambridge arch of northwestern Kansas.

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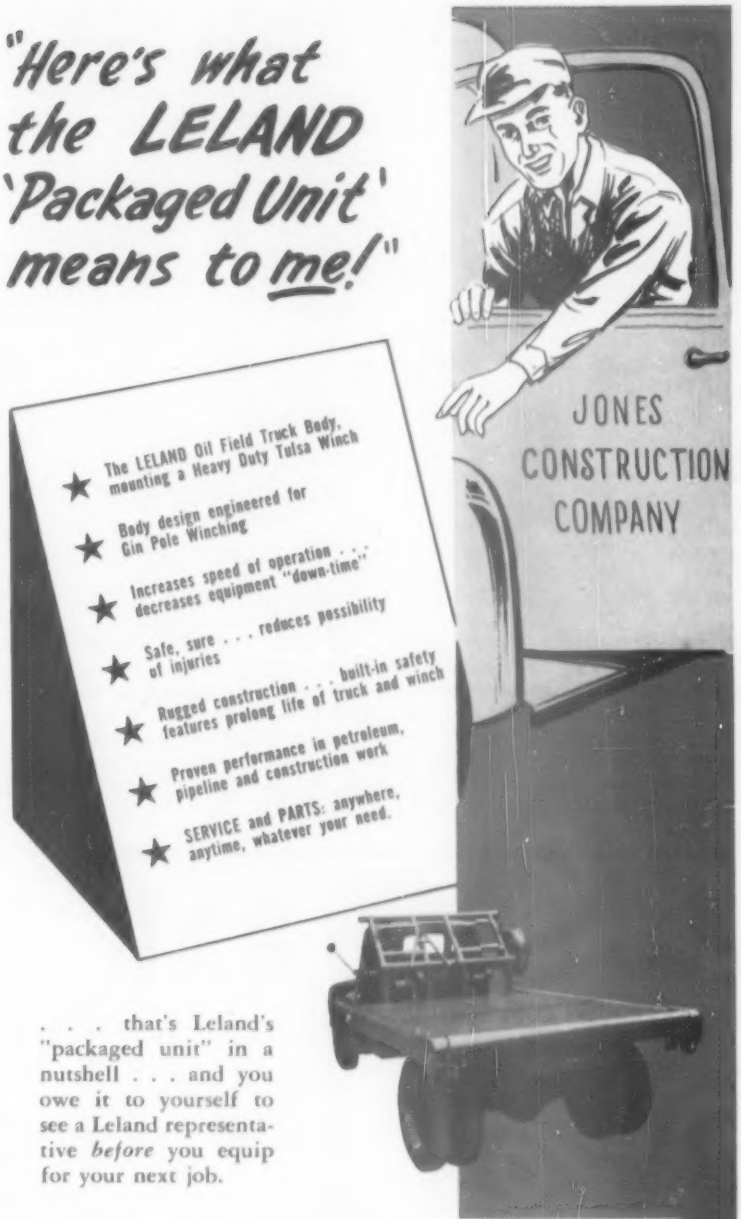

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is the only field of significance on the Cambridge arch itself. The Cambridge arch is the northern extermity of the Central Kansas uplift.

PACIFIC COAST

CALIFORNIA

Santa Fe Springs New Zone Gets Third Producer

Bandini Petroleum Corp. completed 21 Off for an initial production rate of 1,800 bbl. daily to give the new Santa Fe pool in the Santa Fe Springs field its third producer. This latest completion is located approximately 500 ft. east of General Petroleum Corp.'s pool discovery well. The other new Santa Fe pool producer in this old Los Angeles field is Rothschild Oil Co. 1A fee which was completed late last month for 600 bbl. daily. This was a redrill job of an old well located about ½ mile southeast of the discovery.

Judging from its latest test, 244 Santa Fe, located 500 ft. northeast of the discovery, was about to give GP another big producer there. This extension flowed at the rate of 1,200 bbl. daily through ¾-in. choke on the test of the interval 8,507-9,020 ft.

Fourth Test Slated for New San Mateo Field

Union Oil Co. will immediately spud in its fourth test of the new Oil Creek field in San Mateo County. This new well will be drilled on a site ½ mile southeast of the discovery. The site is located SE NE 14-8s-8w. Prior to this, all extension tests of the discovery were drilled north of the original well.

Union suffered its first setback in the field last week when they had to abandon 3 Richfield-Costa after two unsuccessful redrills. This test was drilled from the same site as 2 Richfield-Costa but was slanted to bottom 660 ft. north of the site.

APPALACHIAN

PENNSYLVANIA

In Banks Township, Indiana County, Southwest Pennsylvania, Columbian Carbon Co. 1831 Farmers & Miners Trust Co., wildcat, is now rigging up cable tools to resume drilling. This well has been shut down at 7,398 ft., in the chert which was recorded at 7,393 ft. The new location in Armstrong Township, 1833 Susie Yosurack, is rigging up.

WEST VIRGINIA

Sherman district, Hampshire County, West Virginia, M. E. Anderson, 1 J. E. and B. Orndorff, is drilling at 7,629 ft.

● Licking district, Tucker County, Hope Natural Gas Co. encountered a bad hole at 660 ft. in 9985 J. H. Ludwick.

● Greenbank district, Pocahontas County, Columbian Carbon Co. 1223 U.S.A., elevation 3,591 ft., announced the Oriskany sand at 5,607 ft., with salt water in this formation. Drilling is at 5,780 ft.

In Greenbank district, Pocahontas County, West Virginia, Columbian Carbon Co., 1223 U.S.A. wildcat, elevation 3,591 ft., is drilling at a depth of 5,796 ft., in the Oriskany sand topped at 5,670 ft. No gas or further show of water has been recorded. No. 1220 U.S.A., shut down at 3,300 ft., awaiting the results of this well, has not resumed drilling.

● Licking district, Tucker County, Hope Natural Gas Co. 9985 J. H. Ludwick, is out of the bad hole and is drilling at 953 ft. 9993 Earl Fike, started drilling and is at 20 ft.

● Gore district, Hampshire County, Columbian Carbon Co. 1228 Lonza Kidwell, is at 1,166 ft.

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EASTERN KENTUCKY

In Big Sandy gas field, Kentucky West Virginia Gas Co. has added another good Big Lime (Mississippian) producer at 6,307, A. J. Combs, in Knott County. Located on Troublesome Creek, well flowed initially at the rate of 1,400,000 cu. ft. of gas daily without benefit of shot or acid. A rock pressure of 435 lb. was observed in 68 hours. Lime was topped at 1,907 ft. and bottomed at 1,989 ft. total depth.

OHIO

A second gasser was drilled on the Fred Moore lease, Section 8, Bearfield Township, Perry County, after the first went to water. The operators, Sturm and Sheaf, reported the top of the Clinton at 3,463 ft. and TD at 3,481 ft., still in sand, with a gage of 850,000 cu. ft. natural.

Clinton Oil has established a pool in south center Clayton Township, Perry County, with their 3 Clearfield Coal, Section 21. Clinton at 3,245-3,303 ft. gaged 10 bbl. natural and 148 bbl. in a 24-hour test after treatment.

Midland Oil apparently has a combination well on 1 (4) Walter Hupp, Section 14, Bowling Green Township, Licking County.

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TEXAS PANHANDLE

Ochiltree Scores New Morrow Gas Discovery

Honolulu Oil Corp. 1 Irene Chunn is a new Morrow gas producing area for west-central Ochiltree County, 9 miles east of Spearman. The discovery flowed an estimated 3,000-4,000 M.c.f. per day from perforations in the Morrow sand at 7,798-7,806 ft.

Lecompton Discovery at Quinduno Field Test

A deep wildcat test in Quinduno field, south-central Roberts County, flowed oil from the Lecompton of the Douglas-Pennsylvanian on drill-stem test at 6,230-45 ft. and is now waiting on potential test. The discovery well is Phillips Petroleum Co. 1-A E. Locke, 2 miles northwest of the 2 Gay estate, a dual completion from the Lecompton and Toronto.

On production tests the wildcat flowed 660 bbl. of oil in 24 hours on ¼-in. choke, 491 bbl. the next 24 hours on 22/64-in. choke, and 393 bbl. on 22/64-in. choke on the last 24-hour test.

Douglas Gas Discovery Finaled in Ochiltree

The fast-moving Pennsylvanian campaign in Ochiltree County scored another gas discovery last week. The new pool-opener is Magnolia Petroleum Co. 1 Roy Linn, 13 miles southeast of Perryton town in east-central Ochiltree County.

The discovery well flowed 1,200 M.c.f. of gas per day from perforations in the Douglas sand at 5,754-62 ft. Location is in Section 653, Block 43, H&TC Survey.

OKLAHOMA PANHANDLE

Parker Releases Details On Beaver County Strike

Parker Petroleum Co., Inc., 1 Mitchell, a new Beaver County discovery well 2 miles south and 1 mile west of the three-well Sleeper area Morrow gas area, tested gas at the rate of 9,000 M.c.f. per day with a spray of distillate from the upper Morrow-Penn sand at 7,631 ft. The 12-minute drill-stem test at 7,631-69 ft. surfaced gas in 15 seconds. Maximum flowing pressure was 1,885 psi. and bottom-hole pressure was 2,270 psi.

Parker will test the basal Morrow and Chester - Mississippian lime. This

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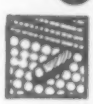

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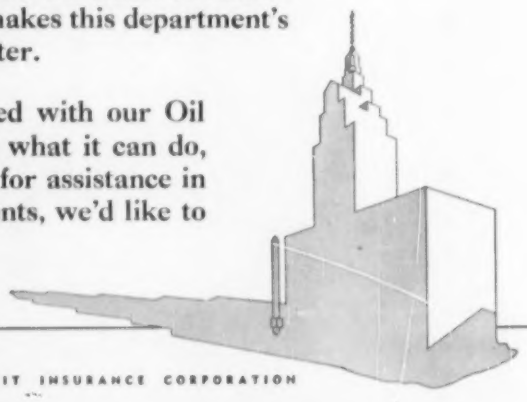
If you are already acquainted with our Oil Loan department, you know what it can do, or if you are looking around for assistance in financing your oil developments, we'd like to *show* you what we can do.



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well is located in C SE¼ NW¼ 3-1n-23eCM.

Southeast Boyd Gas Pool Adds Oil Well

A Morrow oil well has been added to Beaver County's recently-opened Southeast Boyd pool. Union Oil Co. of California 1 Goossen, SW SW NE 15-2n-21eCM, the south offset to the 1 Frantz discovery well, flowed 480 bbl. of oil in 24 hours on 1-in. choke from Morrow sand perforations at 7,143-48 ft.

Southeast Boyd pool was opened several months ago in C SW NE 10-2n-21eCM, flowing 7,750 M.c.f. of gas per day from Morrow sand at 7,108-30 ft.

GREAT LAKES

MICHIGAN

A possible deeper pay objective may be in prospect in Dorr oil pool, Allegan County. The Louis Zellman 1 Helmer, SE NW NE 25-4n-13w, Salem Township, drilled a finely crystalline dolomite porosity section in the middle Salina between 2,746-61 ft. that carried a small amount of free oil and a show of gas after long string of 5-in. casing was set on a bottom perforated joint at 2,758 ft. Amount of oil showing ranged from 1 qt. to 5 gal. of bailer test, but this section may be acidized later. Operator plans to continue deepening to the basal Salina-Niagaran where much earlier test wells in the area have shown for commercial completion in a heavy oil pay. This so-called middle Salina show, above the A beds showed for about 300,000 cu. ft. of gas in another deeper objective test well drilled in the Salem pool further to the west. There is no recorded oil or gas production from this Salina section in Michigan, but the A-1 dolomite Salina zone does produce gas and oil in other rim areas of the Michigan basin.

WEST TEXAS-NEW MEXICO

SOUTHEAST NEW MEXICO

Lea County Devonian Strikes Still Coming

Devonian discoveries in Southeast New Mexico are still the top exploration news. At this writing, one well had been completed and the other was near completion stage. Both are along the north-south trend of previous discoveries, in eastern Lea County.

Crosby area . . . R. Olsen Oil Co., Humble, Amerada et al. 1-D Eva Owen has been completed as a 1,314-bbl. Devonian discovery, or long extension to the new Crosby-Devonian area near Jal. Location is in SW SW 21-25s-37e.

Previous to completion, 1-D Owen flowed 33 bbl. an hour, naturally, through 34/64-in. choke, from perforations at 8,970-9,015 ft. Gas-oil ratio was 1,200:1 and flowing tubing pressure was 300 psi. Initial potential was through the same perforations, choke size was 21/32-in. and tubing pressure was 500 psi. Gravity of the oil was 34°. Sample top on the Devonian was 8,940 ft.

South of Lovington . . . J. C. Williamson 1 Spencer, Devonian discovery prospect in NE NW 25-17s-36e, flowed an estimated 80 bbl. of oil an hour on drill-stem test of the Devonian at 10,850-11,042 ft.

Operators then ran pipe to 11,033 ft. On initial tests of open hole between bottom of pipe and total depth at 11,046 ft., the well flowed oil and mud, amount not estimated. Production tests were to be run as soon as it cleaned up.

Sample top on the Devonian was 11,034 ft. on elevation of 3,816 ft.

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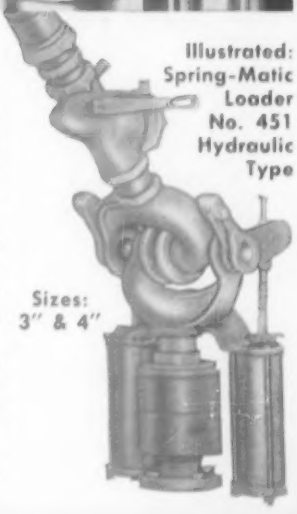
RIGHT NOW, WRITE for the two new six-page folders, descriptive of the new Oilco Spring-Matic loaders, No.'s 451, 451-M, 461 and 461-M, equipped with the No. 856 Swing Joint, which was created to simplify and to speed up the repacking operation.

The illustration demonstrates the process: Remove the flange bolts, roll out the flange assembly, replace the seal, restore the bolts, and the job is done in a twinkling.

This successful swing joint employs three ball bearings — two for the radial load and the third for the thrust load. Perfect alignment of these three bearings insures maximum packing life and smooth, easy vertical movement of the loader.



Illustrated: Spring-Matic Loader No. 451 Hydraulic Type

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Nearest Devonian production is South Knowles field, 15 miles east.

WEST TEXAS

Shell Oil Co. Tests Delaware Basin Prospect

Shell Oil Co.'s 17-A University, Delaware basin wildcat in West Texas, has made a flow of gas and condensate from the Pennsylvanian, one of the deeper formation goals of all basin exploration.

The importance of this deep test lies in its geological location along the eastern rim of the basin, where the formations pinch out against the west flank of the Central Basin Platform. It is in these pinchouts that operators are hopeful of finding oil-bearing stratigraphic traps. According to field sources, geological markers in Shell's well are 6,000 ft. lower than in nearby platform producers, or dry holes, directly east of the well.

Location of the well is in NW NW Section 10, Block 17, University Lands Survey, 6 miles southwest of Wink, in Winkler County. Projected depth was 15,400 ft., with a Corbett Drilling Co. rig.

Pennsylvanian gas flow . . . A drill-stem test at 13,609-40 ft., identified as Pennsylvanian, had gas at the surface in 2 minutes, mud in 5 and condensate in 6 minutes. Operations then had to be suspended 20 minutes for repairs. When opened, the well flowed at the rate of 7,980 M.c.f. of gas a day, through ⅜ and 1-in. top and bottom chokes. At the end of the 21-hour test, gas volume had decreased to 4,860 M.c.f. per day. Condensate yield in 2 hours was 7½ bbl. of 51.4°-gravity yield.

A later gage, through ½-in. chokes, produced 86.75 bbl. of condensate in 15 hours, with gravity up to 62°. Total condensate recovery for the 21 hours was 94.25 bbl.

Wolfcamp tests . . . A drill-stem test at 13,359-83 ft. had gas in 4 minutes, gaged at the rate of 2,400 M.c.f. per day. The tester was open 16½ hours. During the last 10 hours of the test the well made 26 bbl. of 52° condensate.

Upper Permian shows . . . An unidentified section at 5,128-50 ft. blew gas and recovered mud cut with 39.5° oil.

Drill-stem test from 7,294-7,386 ft., probably in the Bone Spring, recovery was 3,500 ft. of gas and 300 ft. of slightly oil and gas-cut mud.

From 11,916-63 ft. gas surfaced in 6 minutes and recovery was 11,000 ft. of heavily gas-cut oil, plus 500 ft. of heavily oil and gas-cut mud, with no water.

At last report, operators were running another test covering the section from 13,609-40 ft., total depth.

Location of Shell Oil Co.'s prospective well on the eastern rim of the Delaware Basin in West Texas.

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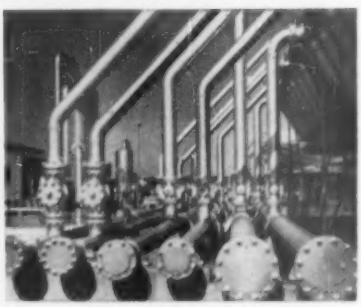

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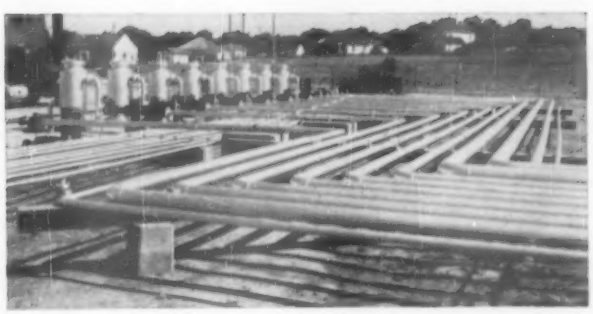

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Regional Meetings of Interest to Geophysicists

The first joint exploration meeting of the Permian Basin Geophysical Society and West Texas Geological Society is scheduled for Friday and Saturday, May 11 and 12, 1956, in the Midland High School auditorium, Midland, Tex.

The program for the meeting is designed with the following goals in view:

1. To explain fundamental techniques of subsurface geological and geophysical exploration for the benefit of geophysicists and geologists respectively.

2. To describe the broad geologic framework and principal geophysical characteristics of selected exploration provinces.

3. To stimulate new exploration thinking with particular reference to problems requiring the joint efforts of both branches of exploration.

To accomplish these objectives the following tentative program has been set up:

Friday, May 11

Fundamental Geologic Techniques, Fundamental Seismic Techniques, Fundamental Gravity and Magnetic Techniques, Geologic Interpretation of Aerial Magnetic Surveys, Geologic Causes of Gravity Anomalies, Application of Combined Geologic and Geophysical Techniques, Panel Discussion of Geologic-Geophysical Coordination, History of West Texas Oil Industry, Provinces for Future Exploration in West Texas and New Mexico, and Coordination of Geologic and Geophysical Efforts.

Saturday, May 12

Geologic of the Midland Basin, Geophysical Characteristics of the Midland Basin, Exploration Case History of a Midland Basin Oil Field, Geology of the Central Basin Platform, Exploration Case History of a Central Basin Platform Oil Field, Geology of the Northwestern Shelf, Geophysical Characteristics of the Northwestern Shelf, Exploration History of the Anderson Ranch Field, Geology of the Delaware Basin, Geophysical Characteristics of the Delaware Basin, and Exploration Case History of Wheat Field, Loving County, Texas.

Eleventh Gulf Coast Meet of S.E.G. Group

The eleventh annual Gulf Coast meeting of the Society of Exploration Geophysicists will be held May 17 and 18 in the Rice Hotel, Houston. Sponsors of this meeting are: the Houston section of the S.E.G., the Geophysical Society of South Texas, Southeastern Geophysical Society, and the Southwest Louisiana Geophysical Society. The program follows:

Thursday, May 17

Magnetic Record Sections for Presentation of Seismic Data, Glenn M. Conklin, Sun Oil Co., Dallas.

Geological and Geophysical Investigation of Sea Mounds in Gulf of Mexico, W. E. Allen, L. Stanley, T. F. Vining, University of Houston.

Difficulties in Seismic Prospecting Resulting from Bubbles in Fluids, J. O. Parr, Jr., San Antonio.

A Marine Seismic Model, George P. Sarrafian, Texas Instruments, Inc., Dallas.

Long Interval Velocity Logger, Frank Kokesh, Schlumberger Corp., Houston.

Recent Geophone Development, Ernest M. Hall, Jr., Electro-Technical Labs, Houston.

Accident Facts—1955, S.E.G. Safety Committee, William H. Newton, General Geophysical Co., Houston.

Friday, May 18

Future Offshore Oil Provinces, T. R. Goedicke, Offshore Exploration Group, Houston.

New Methods and Equipment for Seismic-Data Processing, Hal J. Jones, Houston Technical Labs, Houston.

Time-Depth Conversion Camera, Gordon Perry, Texas Instruments, Inc., Dallas.

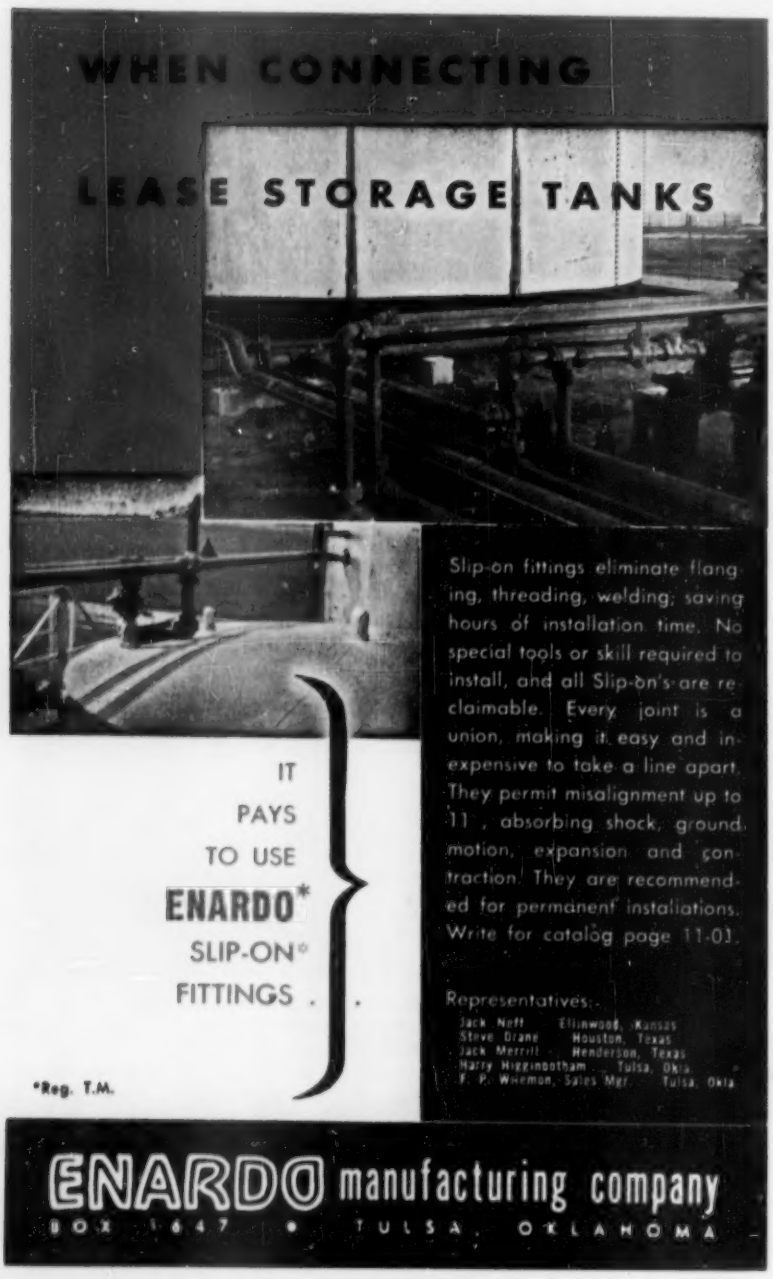
Seisex-Seismogram Section, Sam M. Pena, Marine Exploration Co., Houston.

Chacahoula Dome, A Case History, W. E. Hollingsworth and H. C. Weston, Sun Oil Co., Beaumont.

Geologic Interpretation of Aerial Magnetics, James Affleck, A.A.P.G. Distinguished Lecturer, Gulf Oil Co., Pittsburgh.

Basic Principles of FM Recording in Seismic Tape Machines, R. W. Kelley, Houston Technical Labs, Houston.

Direct Recording Versus FM Recording in Seismic Tape Machines, Louis W. Erath, Southwest Industrial Electronics Co., Houston.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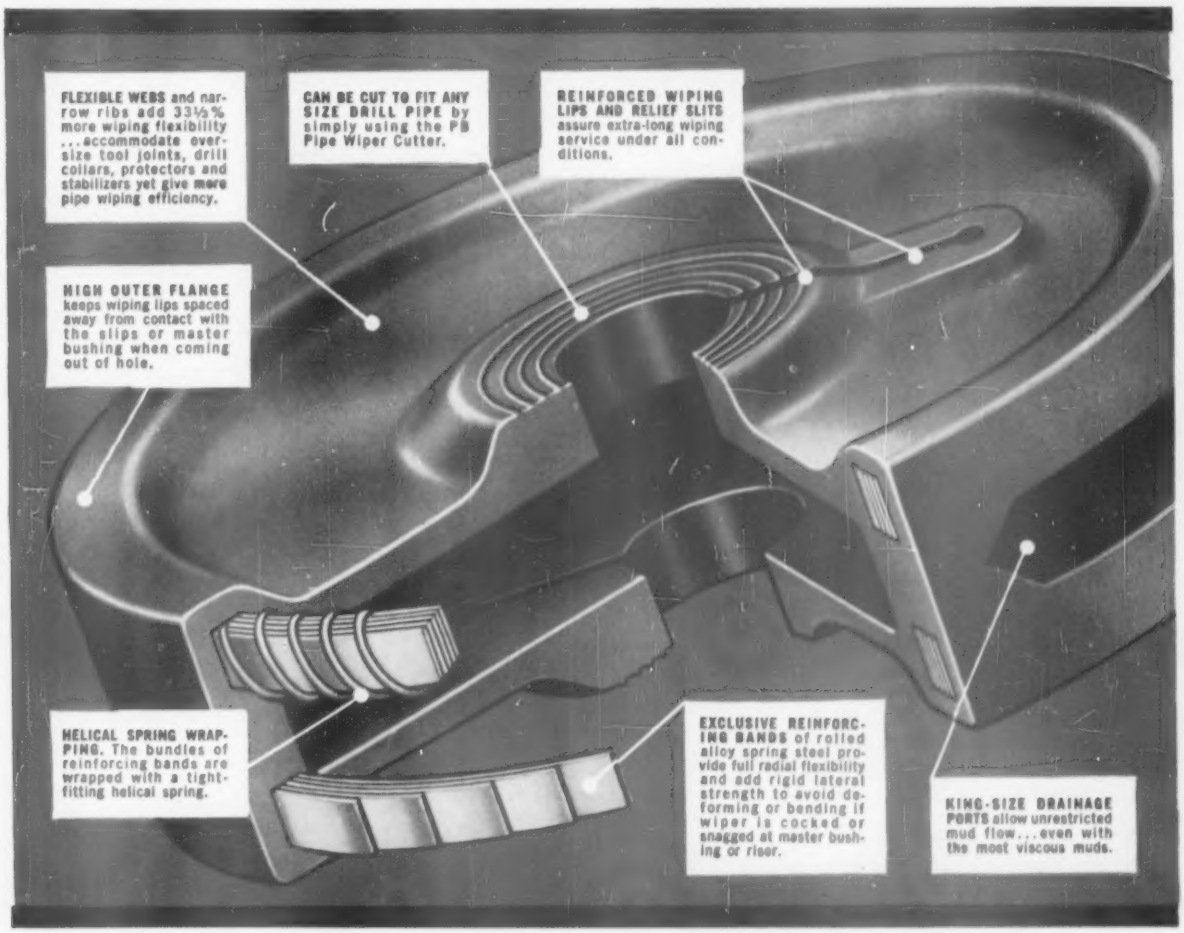
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CALIFORNIA

Kern County: Gilliland Oil Co. 1 Bandini-U.C., SW NE 3-25s-18e, 144 BOPD, 40.5° gravity, 22/64-in. choke, perfs. 3,602-68 ft., TD 4,007 ft. (New Avenal sand pool discovery in Dagany Gap region of Devils Den field.)

COLORADO

Delta County: Minerals Engineering 2 Billstrom, SE SE SE 10-14s-95w. IP est. 2,200 M.c.f. of gas per day, Dakota discovery, new field. TD 690 ft. Dakota.

ILLINOIS

Douglas County: C. B. Earnest 1 Pflum, SW SW SE 11-15n-7e. IPP 155 BOPD, Rosiclare 1,654-62 ft. 39.4°. TD 1,676 ft. Opens Bourbon field.

SOUTH LOUISIANA

Lafayette Parish: Sunray Mid-Continent Oil Co. and Buffalo Oil Co. 1 Carver, 21-10s-3e. IP 60 BCPD and 2,800 M.c.f. daily, 5/32-in., 46.8°, perfs. 11,953-57 ft. TD 12,025 ft. (New pay in Ridge field.)

St. Martin Parish: Aluminum Co. of America 1 St. John, 69-10s-7e. IP 303 BOPD and 742 M.c.f. daily, 11/64-in., 35.4°, perforations 11,423-29 ft. and 11,434-41 ft. TD 14,106 ft. (New pay and extends Section 28 field.)

St. Mary Parish: Fifteen Oil Co. 13 Veeder-Hunt, 30-13s-10e. IP 89 BOPD, ⅛-in., 28°, perforations 2,990-94 ft. and 2,999-3,006 ft. TD 5,287 ft. (New pay in Charenton field.)

Terrebonne Parish: Placid Oil Co. et al. 2-B LL&E, 23-20s-18e. IP 82 BOPD (net), 5/32-in., 26 per cent water, perforations 15,025-35 ft. TD 15,038 ft. (New pay in Lapeyrouse field.)

Kerr-McGee Oil Industries, Inc., 1-G State Lease 752, Block 30, Ship Shoal Area, Gulf of Mexico. Shut-in gas well, no gage, perforations 11,534-55 ft. TD 11,950 ft. (New pay in Ship Shoal Block 32 field.)

NEBRASKA

Kimball County: Roh Oil-Walker-Wilson Drilling Co. 1 Swisher, C NW SW 5-13n-54w. IPP 112 BOPD, "D" sand discovery, new field. TD 6,205 ft. Skull Creek.

Morrill County: British-American Oil Producing Co. 1-D Craig, C NW SW 23-19n-52w. IPP 203 BOPD, "J" sand discovery, new field. TD 4,690 ft. "J" sand.

NORTHWEST NEW MEXICO

San Juan County: British-American 1 Marya, NW NE NE 1-25n-13w. IPP 595 BOPD, Gallup discovery, new field. TD 5,000 ft. Gallup.

NORTH DAKOTA

Williams County: Amerada Petroleum Corp. 1 F. L. Kahlert, SE NW 7-154n-95w. IPP 104 BOPD, Madison discovery, new field. TD 8,571 ft.

OKLAHOMA

Kingfisher County: Utah Southern Co. 1 Pope, 17 miles SE of Ringwood field in SW SE NW 10-18n-9w. IPF 7 BDPD, 4,000 M.c.f. of gas per day, Inola 7,265-75 ft., 24/64-in. choke, 48°, TD 7,670 ft. (Gas-distillate discovery.)

SASKATCHEWAN

Central-Del Rio 4-2 Ralph, LSD 4, 2-7-13w2. TD 4,604 ft. Mission Canyon oil well.

TEXAS PANHANDLE

Ochiltree County: Superior Oil Co. 1 C. H. Oringderff, 5 miles SW of Perryton in northcentral part of county, 8 miles northeast of Farnsworth pool in Sec. 21, Blk. 12, H&GN Sur. IP 7,300 M.c.f. of gas per day plus 40 BDPD, 22/64-in. choke, 71°. Morrow sand 7,919-25 ft. TD 8,359 ft. (Gas-distillate discovery).

The Texas Co. 1 C. D. Conner, 3½ miles northwest of oil production in Farnsworth area, 1 mile south of Farnsworth in Sec. 5, Blk. JT, TWNG Sur. IPF 636 BOPD, 1-in. choke, based on 318 BO in 12 hours, 43.3°, GOR 755:1. Des Moines-Penn 6,719-31 ft. and 6,747-51 ft. TD 6,780 ft. (Oil discovery).

Ochiltree County: Magnolia Petroleum Co. 1 Roy Linn, 3½ miles NW of 1 J. W. Parnell discovery, 13 miles SE of Perryton in Sec. 653, Block 43, H&TC Sur. IPF 1,200 M.c.f. of gas per day, Douglas 5,754-62 ft. GOR 537,000:1. TD 9,200 ft. (Gas discovery.)

TEXAS GULF COAST

Jackson County: Progress Petroleum Co. of Texas 1 Hornbuckle, Jesse White Sur., A-82. IP 56,000 M.c.f. daily, open-flow potential, GLR 37 M.c.f. per bbl., 59.4°, perforations 7,172-82 ft. TD 7,500 ft. (New field.)

UTAH

Uintah County: F. R. Anderson 42-9 Government, NW SE NE 9-7s-22e. IP 124 M.c.f. of gas per day, Uinta discovery, new field. TD 4,553 ft. Green River.

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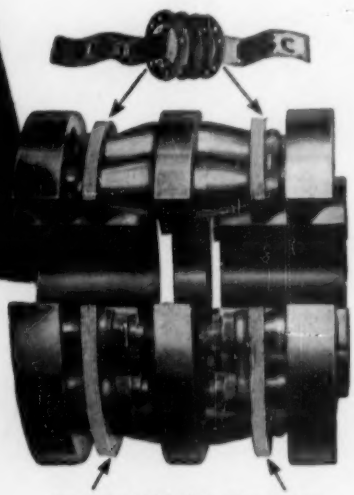

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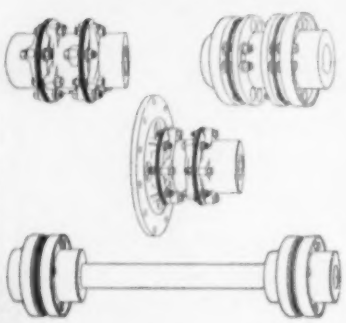

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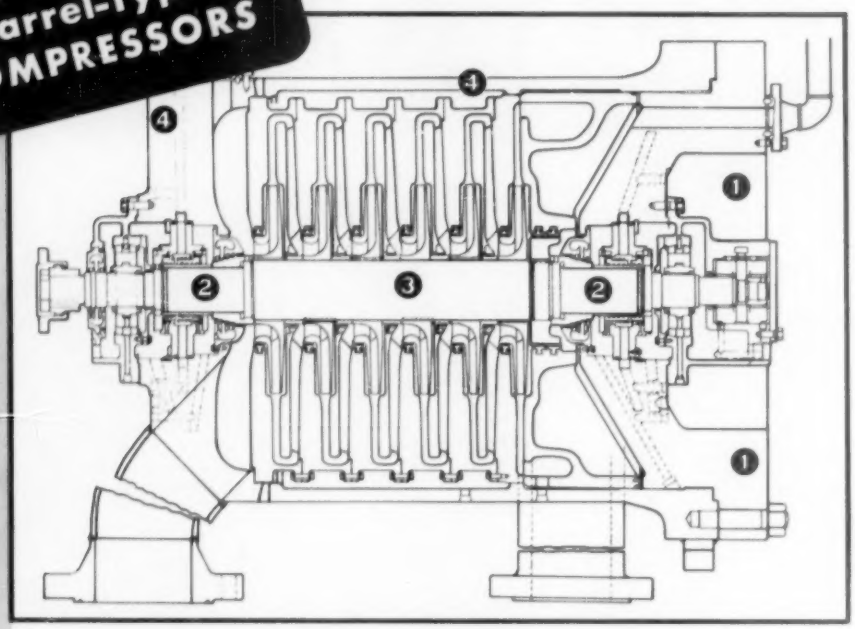


Features:

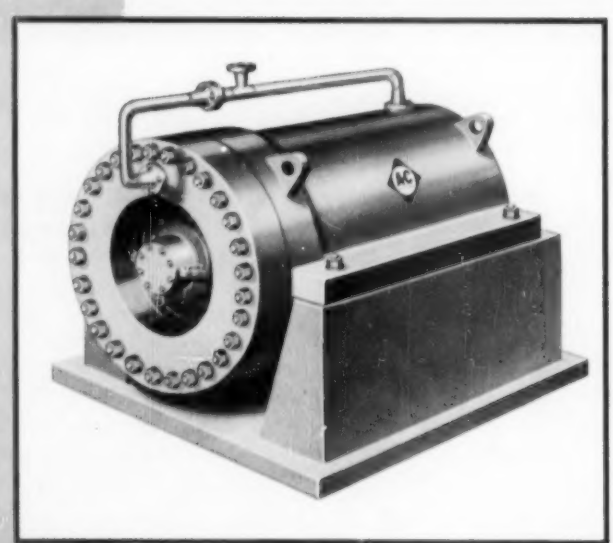
❶ **Simple to Maintain — Only one head bolted on. Spiral-wound metallic head gasket can be installed without cement or grease—quickly removed and reused if needed.**

❷ **Shaft Sealing — Double bushing seals with separate high pressure seal oil system. Inward seal leakage minimized.**

❸ **Rugged Rotor — For years of high speed operation. Impellers shrunk and keyed to shaft. Rugged riveted impellers with rivets milled integrally from blade edge.**

❹ **Extra Strong — Vertically split forged steel casing — safe at high pressures.**

Here's Unit Chosen for Reforming Process



This compressor is typical of Allis-Chalmers high pressure barrel units for "upgrading" processes.

Above are a few of the features that make it easy for maintenance men to keep equipment on stream around the calendar. Details of this design are yours for the asking. Call your nearby A-C office or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wis.

A-4967

A-C ALLIS-CHALMERS

ALLIS-CHALMERS

One gets a new title as . . .

Famous Brothers Get Together

TWO of the Western Hemisphere's most prominent geologists — the Link brothers — caught up on their small talk last week at the forty-first annual meeting of the American Association of Petroleum Geologists.

Walter K. Link (at left), now a consultant to the Brazilian Government oil company, Petrobras, was on hand to see his older brother, Theodore A. (Ted) Link, installed as president of the organization of which he has been a member since 1920.

Theodore Link, president of Link, Downing & Cooke, Ltd., consultants of Calgary and Toronto, was long associated with the Jersey Standard group of companies. He succeeds G. M. Knebel, exploration manager of Standard Oil Co. (N. J.), as head of the A.A.P.G.

Walter Link, a former chief geologist for Jersey, has worked for the international company in North, South, and Central America, and the Netherlands East Indies.

Early background . . . The new A.A.P.G. president is 59 and a native of La Porte, Ind.

His experience ranges from oil-company and independent exploration in Canada, the United States, and South America, to government survey work.

After earning a B.S. degree in geology from the University of Chicago in 1918, he became assistant geologist for the Geological Survey of Canada.

His first exploration job was in the Mid-Continent area with Empire Gas & Fuel Co. In 1919 he joined Imperial Oil, Ltd., and subsidiaries as a geologist, beginning an association that was to last for 27 years.

He was in Colombia from 1922 to 1926 with Tropical Oil Co., an Imperial affiliate, leaving this post to study for his Ph.D. degree in geology, which he received in 1927.

Link then worked for Imperial in western Canada, an area in which he is now one of the best known exploration men. He took time out in 1933 to direct the Petroleum Industries Exhibit at the Century of Progress, Chicago. By 1944 he had risen to assistant chief geologist for Imperial and 2 years later was named chief geologist. He resigned in 1948 to become an independent consultant.

Consulting work . . . In this capacity Ted Link was in charge of the joint exploration program of a group composed of leading Canadian independents as well as several major United States companies.

After 6 years on his own, Dr. Link joined A. J. Downing and D. Y. Cooke in the firm of Link, Downing & Cooke, Ltd., which he still heads.

Link, a member of the A.A.P.G. for 36 years, has been active in the association during most of that time. He has served on the business committee intermittently since 1930 and was chairman of the group in 1948, 1950, and 1952-54.

He has been an associate editor since 1935, and has been a member of the research committee, a distinguished lecturer, and in 1950-51 was vice president of the association.

Besides the A.A.P.G., Link is affiliated with the Canadian Institute of Mining Engineers, American Geophysical Union, American Association for the Advancement of Science, Geological Society of America, and American Institute of Mining, Metallurgical and Petroleum Engineers.

A prolific author, he has written several major scientific articles on structural and stratigraphic geology, reef formation, and the origin of oil.

R. E. Johnston, independent producer and operator, has opened offices in Denver to specialize in Denver-Julesburg, San Juan, and Powder River basin exploration and development. **R. E. Duty** will be geological consultant to Johnston.

Ted W. Ballard, Houston consulting seismologist, has been named director of geological surveys for American Minerals Exploration Co. of Houston. One of his chief functions will be to correlate and interpret data gathered by A.M.E.C.'s new aerial photo-radiometric survey unit.

P. H. Bohart, vice president of Gulf Oil Corp.'s Tulsa production division since 1950, will be transferred May 1 to Pittsburgh as vice president for planning and economics. He'll also head the economics review council, which conducts studies for future planning. **S. G. Sanderson,** production manager

P. H. BOHART

S. G. SANDERSON

in the Tulsa division, becomes division manager. Bohart joined Gulf in 1919 as a geologist. From 1920 to 1924 he was with Mexican Gulf Oil Co., and in 1924 moved to Tulsa as vice president of Gypsy Oil Co. and Gulf Pipe Line Co. of Oklahoma. Sanderson joined Gulf's natural-gas department in 1913 and later became superintendent of natural-gasoline plants. He was named general production superintendent for Gypsy in 1929.

Personals

W. W. (Bill) Keeler, vice president and director of Phillips Petroleum Co. and a refining industry veteran, has been elected executive vice president, a newly created post. Keeler joined Phillips in 1924 as a youth of 16. He worked during school vacations in the firm's engineering department in the Burbank field gasoline department and in the Bartlesville, Okla., research laboratories. In 1929 Keeler went with Phillips full-time as a chemist. He advanced to process engineer, night superintendent, and chief engineer at various Phillips refineries until, in 1943, he was named technical assistant to the vice president in Bartlesville. He became manager of all refining operations in 1945, and was elected a vice president in 1947. Prominent for many years in Indian affairs, Keeler was appointed principal chief of the Cherokee Nation in 1949, by President Truman. He established the Cherokee Foundation, devoted to raising the tribe's social and economic status.

R. S. Mahannah and **B. M. Veilleux** have been named district geologists in two new Shell Oil Co. exploration districts. Mahannah, since 1953 a Shell geophysicist in Calgary, will head the Plains district, part of the Calgary exploration division. Veilleux, who joined Shell in 1949 as geologist, will head the Edmonton district, part of the Edmonton division.

Alex Johnston, Tulsa, 64, board chairman of Sinclair Crude Oil Co., has announced as a Democratic candidate for U. S. representative from Oklahoma's First Congressional District. A former vice president of Sinclair Oil & Gas Co., he has been chairman of the crude company since its formation in 1953. Johnston's campaign will stress immediate reenactment of Harris-Fulbright type natural gas legislation.

Dan Kralis, Abilene, Tex., consultant, has announced as a Democratic candidate for U. S. representative of Texas' 17th Congressional District. He'll oppose Rep. Omar Burleson, Anson, Tex., who has filed for reelection. Kralis will campaign on a five-point platform calling for, among other things, a raise in the depletion allowance from 27½ to 40 per cent. He heads Petroleum Management, Inc., headquartered in Abilene.

Torkild (Cap) Rieber, world-traveled president of Barber Oil Co. and former board chairman of The Texas Co., has been elected Barber's first chairman of the board. He'll remain chief executive officer. Rieber walked off his Norwegian tanker to join Texaco as that firm loaded Spindletop crude aboard the ship in Beaumont over 50 years ago. A string of colorful posts in and out of Texaco culminated in his election as chairman in 1933. The company's major overseas expansion from 1935-40 came with Rieber at the helm. Rieber has headed Barber since 1942. In 1946 he bought control of American Republics Corp., which he had headed in 1926 while working with J. S. Cullinan. **James H. Durbin,** Barber vice president since March 1955, succeeds Rieber. Durbin was executive vice president of American Republics.

Frank C. Smith, board chairman of Houston Natural Gas Corp. and former president (1953) of the American Gas Association, has been elected 1956 chairman of the board of trustees of the Institute of Gas Technology, Chicago. Smith served as the Institute's first chairman from 1941 to 1946.

A. E. Pettit, Houston consultant, has joined Sohio Petroleum Co. as staff geologist in New Orleans. He'll be assigned to the firm's offshore venture there. Pettit is a former assistant to the president of Louisiana Land & Exploration Co.

F. B. (Duck) Haverfield has been promoted by Transcontinental Gas Pipe Line Corp. from superintendent of compressor stations to general superintendent. He succeeds **Walter H. Davidson,** who was elevated to operations vice president *(The Oil and Gas Journal, April 23, page 200).* Davidson had been vice president and general superintendent. Before joining Transco in 1950, Haverfield was gasoline division manager for Continental Oil Co. He had been with Conoco 24 years. Davidson joined Transco in 1950 as operations superintendent after a year with Fish Northwest Constructors as general construction superintendent on the Transco project. Earlier he was assistant operations superintendent for Natural Gas Pipe Line Co. of America.

DAVIDSON

HAVERFIELD

Dr. Sylvain J. Pirson last week (April 23) was erroneously reported to have resigned from the University of Texas' petroleum engineering department to join a Denver consulting firm. The consulting work actually will be a temporary assignment during the coming summer months. Pirson remains with the university.

John M. Sprague, vice president of Carter Oil Co. for about a year, has been named vice president for manufacturing and marketing. He'll be headquartered in Billings, Mont., operations center of Carter's nine-state marketing operation and home of its 25,000-bbl. daily refinery. Sprague joined Carter in 1936 as an accountant. He later became chief accountant and comptroller. In 1954 he was named to head the firm's Eastern division operations (Illinois, Michigan, Indiana, and Kentucky) in Mattoon, Ill.

James A. Millen, a vice president and head of supply and transportation for Southern Counties Gas Co., has been elected a director.

Raymond B. Kelly, Pure Oil Co.'s exploration and production vice president, has been named to the executive committee. Kelly, with Pure 31 years, has been a director since 1954. During World War II he directed Petroleum Administration for War's Production District No. 2.

Dr. George S. Bays, formerly with Humble Oil & Refining Co.'s coordination and process departments in Baytown, Tex., has been named manufacturing manager of International Petroleum Co. (Colombia), Ltd. Bays joined the technical services division of Humble's Baytown refinery in 1936. In 1941 he went to the Baytown Ordinance Works, operated by Humble during the war, and 2 years later became assistant superintendent there. His next post was in Humble's Houston headquarters. Then he returned to Baytown for training.

Michael T. Halbouty, Houston engineer, geologist, and independent operator, has been elected president of Houston's Petroleum Club. Other new officers: **Wilbur L. Ginther,** first vice president; **Randolph Yost,** second vice president; **Logan H. Bagby, Jr.,** secretary; **A. L. Selig,** treasurer; and **B. C. Martin,** assistant secretary and treasurer. Elected new directors were: **George C. Hardin, Jr.,** Bagby, and Selig.

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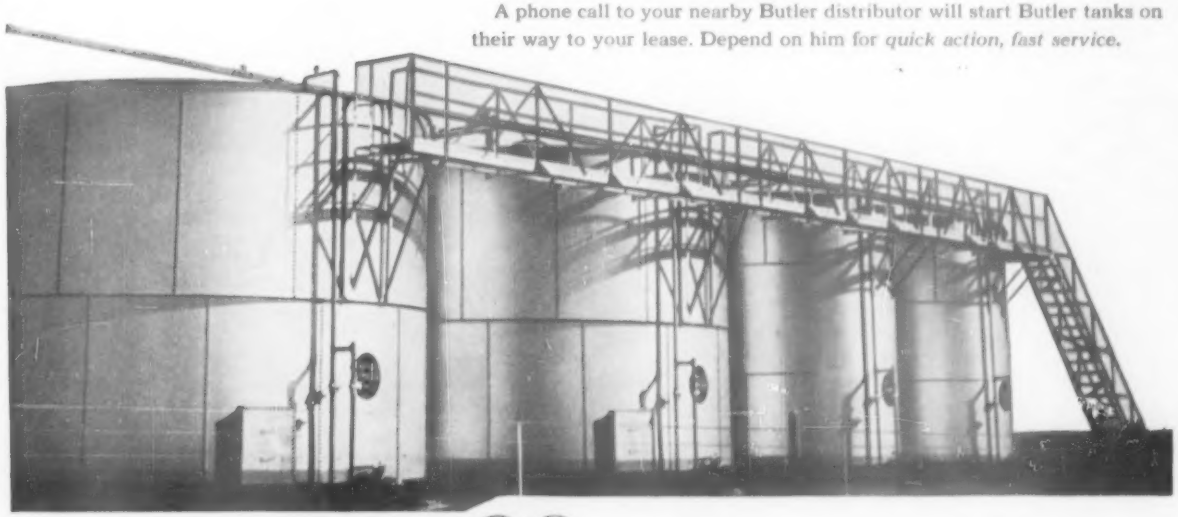

UNION TANK AND SUPPLY COMPANY

Abilene, Texas	Midland, Texas	New Orleans, La.	Wichita, Kan.
Alice, Texas	Nacona, Texas	Ardmore, Okla.	Kimball, Nebr.
Beaumont, Texas	Odessa, Texas	Cushing, Okla.	Denver, Colo.
Dallas, Texas	Hobbs, N. M.	Oklahoma City, Okla.	Fort Morgan, Colo.
Fort Worth, Texas	Dubach, La.	Tulsa, Okla.	Sterling, Colo.
Houston, Texas	LaFayette, La.	Great Bend, Kan.	Casper, Wyo.
Kilgore, Texas	Lake Charles, La.	Plainville, Kan.	Powell, Wyo.

AMERICAN PIPE AND SUPPLY COMPANY
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Personals

G. S. ORMSBY

George S. Ormsby has resigned as assistant director of Phillips Petroleum Co.'s drilling-engineering division, Houston, to join International Drilling Co. as division manager in The Hague, the Netherlands. Ormsby replaces **J. N. (Bo) Biron,** who moves to Rome as general superintendent. Biron is a former division drilling engineer for Gulf Oil Corp. in Houston. International now operates a rig in Holland, one in Italian Somaliland, and has contract for core drilling on the island of Malta.

Howard L. Cline, Houston, has been promoted by Transcontinental Gas Pipe Line Corp. from assistant superintendent to superintendent of compressor stations. Before joining Transco in 1951, Cline was assistant superintendent of compressor stations for Cities Service Gas Co.

Connie L. Wilson, Sinclair Oil & Gas Co. general staff petroleum engineer, has been named assistant division manager in the Fort Worth division. Wilson joined Sinclair as division engineer in 1951. **John B. Etnyre** has been transferred from New Orleans and promoted to division geophysicist for the new Midland division *(The Oil and Gas Journal, April 23, page 197).* **John K. Lydecker,** former district geologist for American Republics Corp., becomes division geologist in Midland. **Herbert F. Defenbaugh** has been named division production superintendent there. Etnyre joined Sinclair in 1950 as geologist. Defenbaugh started as production engineer in 1939.

John N. Huber has resigned as district geologist for Tide Water Associated Oil Co. in Casper, Wyo., to become an independent geologist there.

D. N. McBRIDE

M. E. (Bones) Foster, with Phillips Petroleum Co. 32 of his 37 years in the oil business, has resigned as president of Phillips Pipe Line Co. and will retire June 30. He'll become a supply and transportation consultant in Bartlesville, Okla. **Don N. McBride,** manager of Phillips' supply and transportation department, has been named to succeed Foster. He continues as supply and transportation manager. **Myron O. Johnson** was named a vice president and general manager of the pipeline company.

DEATHS

John Raymond Manion, 80, retired vice president of the old Sinclair Refining Co. and pioneer pipeliner, died April 21 in Tulsa. Manion retired in 1947 after 54 years in the industry. He began in 1891 as engineer with Pennsylvania Pipe Line Co. after oil was discovered in the state's McDonald field. In 1904 he left eastern oil fields to become a district foreman for Prairie Pipe Line Co. in Bartlesville, Okla. When Sinclair formed Sinclair-Cudahy Pipe Line Co. in 1916, Manion became general manager. He became president of the firm in 1920, and later was named vice president of pipelines for Sinclair Refining. A prominent Catholic layman, he was a member of the exclusive papal order of Knights of the Holy Sepulchre, one of the highest honors bestowed by that church.

Lawrence D. Hibbs, 61, Tulsa independent operator, died there April 20. He had been active in the Tulsa area since 1920.

Clinton Solt, 63, with Gilcrease Oil Co. in San Antonio, died there April 20. He was a former treasurer of Valley Osage Oil Co., Tulsa.

T. H. A. Tiedemann, 66, who helped establish the personnel and employe-relations program of Standard Oil Co. (N. J.), died April 15 in Baltimore. Tiedemann retired in 1951 as a director of Industrial Relations Counselors, adviser to a number of large firms. He had been with Jersey Standard during the 1920's.

Edwin L. Hall, 53, director of American Gas Association's Cleveland laboratories and international authority on gas manufacturing, died recently in Cleveland. Hall was also assistant managing director of the Association. In 1950 he received the A.G.A. distinguished-service award for the outstanding individual contribution toward the advancement of the gas industry.

Pierce Larkin, 78, veteran geologist, died April 20 at his home in Tulsa after a long illness. He was one of the first graduate geologists from the University of Oklahoma and later taught geology at Oklahoma and the University of Texas. Larkin practiced as a consulting geologist for many years, working up oil geology prospects in Alaska, South America, Mexico and the United States. He later joined Gilcrease Oil Co. as chief geologist and played a prominent role in that firm's rapid successes.

Norman Frederick Le Jeune, 59, for 20 years assistant manager of Tide Water Associated Oil Co.'s now-dismantled Bayonne, N. J., refinery, died April 15 in New York. He had been with Tide Water since 1927.

Russell Alexander Young, 54, secretary-treasurer and a director of Anglo-American Exploration, Ltd., died April 20 in High River, Alta.

Thomas Earby McGlathery, 60, active independent in East Texas boom days, died April 24 in Dallas. He retired in 1939.

L. A. Grelling, 63, Tyler, Tex., prominent as an independent since the early 1920's, was killed recently when his private plane crashed off the Bahama Islands. His wife, Mrs. May Kyle Shumway Grelling, and pilot, O. S. (Clyde) Barrow, also were killed. Grelling joined Humble Oil & Refining Co. after World War I. Later he spent 5 years with U. S. Tex Oil Corp. before going on his own when that firm dissolved. Grelling held producing properties in Texas, Oklahoma, Arkansas, Louisiana, and Mississippi. He was a director of Independent Petroleum Association of America, Mid-Continent Oil and Gas Association, and Texas Independent Producers and Royalty Owners Association.

George Hamlin Shaw, 65, vice president and director of Cities Service Co., died last week while at the company's annual meeting in Dover, Del. An attorney, Shaw joined Cities Service in 1935 as industrial relations director. He became a director 3 years later and was made a vice president in January.

John Logan Hazzard, 70, early-day Kern River field driller, died April 16 in his Bakersfield, Calif., home.

Guy H. Cherry, 81, president of Five C Refining Co., Santa Maria, Calif., since 1938, died April 12 in Los Angeles.

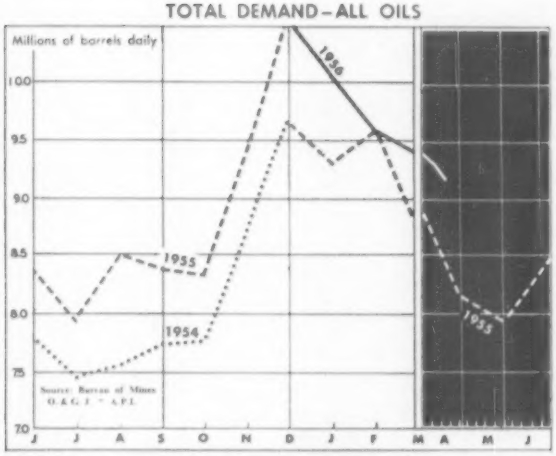
J. W. Templeton, 38, assistant landman for Seaboard Oil Co. in Abilene, Tex., died there April 20.

Latest Figures . . . Industry Trends

A QUICK LOOK AT THE HIGHLIGHTS

	LATEST WEEK	Change from WEEK AGO		Change from YEAR AGO	
Production	7,177,150	DOWN	16,650	UP	280,610
Crude stocks	267,085,000	UP	3,262,000	DOWN	4,340,000
Completions	1,141	UP	80	UP	62
Refinery runs	7,436,000	DOWN	115,000	UP	337,000
Gasoline stocks	192,933,000	DOWN	2,126,000	UP	13,192,000
Kerosine stocks	18,070,000	UP	463,000	DOWN	2,359,000
Distillate stocks	61,926,000	UP	1,094,000	DOWN	3,752,000
Residual stocks	32,829,000	UP	41,000	DOWN	11,790,000
Four-product stocks	305,758,000	DOWN	528,000	DOWN	4,709,000
Total imports	1,242,600	DOWN	28,400	UP	215,300

TOTAL DEMAND—ALL OILS



Cooler Weather Boosts Product Demand, Higher Demand Prevents Soft Markets

WEATHER has been an important factor in the high demand for products in the last half of March and the first half of April. Temperatures have been below normal in the areas where demand for home-heating fuels is important, and yet the brand of weather has not prevented normal increases in gasoline consumption.

For the 4-week period ended April 13, gasoline demand was up about 6 per cent over the same period last year. Distillate demand gained 20 per cent. Kerosine demand, which showed very little gain early in the winter, has been up about 12 per cent compared with the same weeks a year ago.

These trends in demand are influencing product markets. Distillate fuels on the Gulf Coast are reported to be holding up better than in past years. Suppliers on the East Coast have no surplus heating oils left over from the winter season. Primary stocks are definitely below normal. Secondary suppliers have been hunting fuel rather than customers with each new wave of cooler-than-normal weather.

The fact that distillate has been the big factor in demand gains for March and early April should influence any revisions in demand forecasts for the year. Demand for the fourth quarter still should be based on normal weather.

Top-quality gasolines are scarce on the Gulf Coast. Normal premium gasoline, 97 octane, is very firm with material hard to find at the low of 13.0 cents a gallon. The 98-octane premium carries a quotation of 13.25 cents a gallon, but there are no reports of offers on the spot market.

Most Mid-Continent refiners expect Group 3 gasoline prices to move up about the first of May. Individual opinions as to the amount of the increases average out at about 0.5 cent for regular and 0.75 cent for premium.

May demand will be lowest of the year . . . Total demand for petroleum products turns downward after the peak of the heating season and normally hits the low point of the year in May. Also, refined product stocks normally reach bottom early in May.

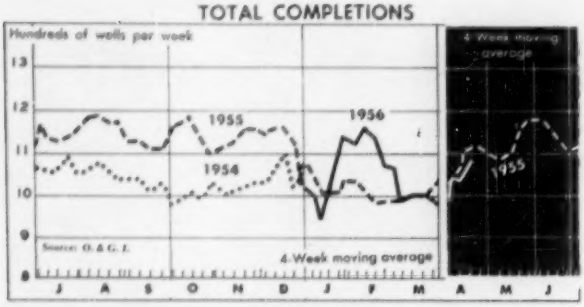
The table below shows trends in demand, refinery runs, crude production, and refined-product stock changes. The averages are based on data for years 1950 through 1955, omitting the abnormal year 1952. Total demand in May has been 91.6 per cent of the daily average for the year. In contrast, runs averaged 98.9 per cent and crude production 99.0 per cent. Product stocks normally increase 4.3 per cent during May.

PETROLEUM TRENDS
(Years 1950-55)

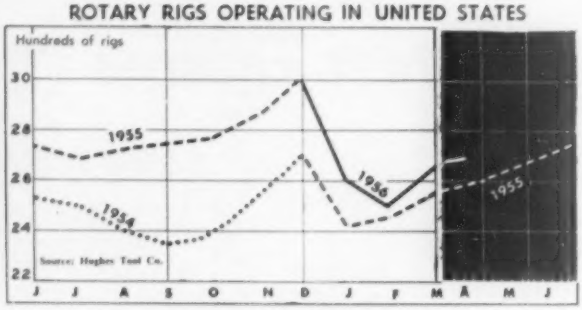
	Total* demand	Refinery* runs	Crude* production	Product† stock ch.
January	105.6	98.9	97.5	—3.0
February	105.1	99.4	98.4	—2.5
March	102.0	98.3	99.0	—1.9
April	95.8	95.3	99.5	0.1
May	91.6	98.9	99.0	4.3
June	95.8	100.2	100.1	2.1
July	93.1	100.8	99.9	3.8
August	96.2	101.6	100.5	2.6
September	96.6	101.2	101.3	2.3
October	97.4	100.1	101.0	1.8
November	105.8	102.0	102.0	—1.1
December	115.3	103.0	101.7	—5.4

*Per cent of daily average for year. †Per cent change.

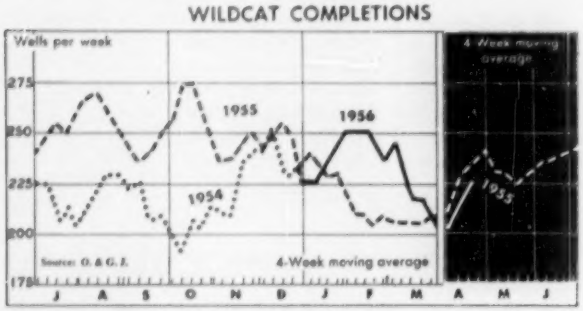
TOTAL COMPLETIONS



ROTARY RIGS OPERATING IN UNITED STATES



WILDCAT COMPLETIONS



ACTIVE ROTARY RIGS*

Area—	4-23-56	Change from 4-16-56	Change from 4-25-55
Gulf Coast	646	13	65
N. and W. Texas-New Mexico	927	—3	66
Arkansas-N. Louisiana-E. Texas	175	—2	13
Oklahoma	309	—24	—11
Kansas-S. Nebraska	180	5	—11
Illinois-Eastern	112	15	—40
Rocky Mountain	211	4	9
Pacific Coast	135	2	—22
Total United States	2,695	10	69
Western Canada	95	—13	—10

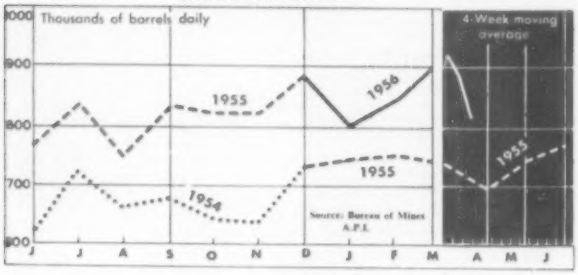
*Hughes Tool Co.

WEEKLY WELL COMPLETIONS . . . WEEK ENDED APRIL 21, 1956

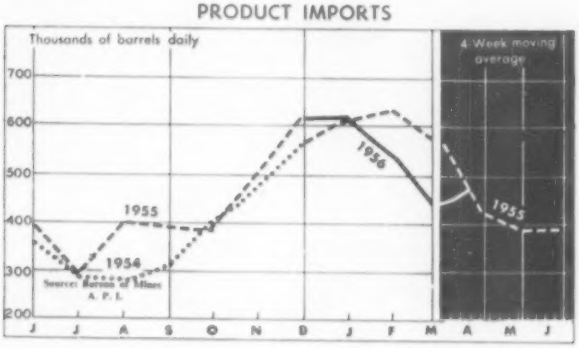
	Total of all wells: Comp.	Oil	Gas	Dry	Footage	Cum. 1956	Cum. 1955	Wildcat completions and discoveries: Oil	Dist.	Gas	Dry	Total	Cumulative total, 1956: Oil	Dist.	Gas	Dry	Total
Ala.-Ga.-Fla.	3	1	0	2	21,038	32	33	0	0	0	2	2	0	0	1	17	18
Arkansas	14	6	1	7	47,458	229	201	0	0	0	4	4	11	0	2	36	49
California	48	33	1	14	229,499	644	781	3	0	0	11	14	14	0	0	130	144
Colorado	32	4	5	23	154,316	343	395	0	0	2	13	15	6	0	6	158	170
Illinois	65	32	0	33	159,717	997	1,096	4	0	0	11	15	17	0	0	160	177
Indiana	7	2	0	5	14,365	184	218	0	0	0	0	0	5	0	1	37	43
Kansas	79	33	6	*40	258,407	1,510	1,536	2	0	0	14	16	35	1	10	257	303
Kentucky	19	6	6	7	36,652	494	373	0	0	0	1	1	9	0	0	111	120
Louisiana	86	52	6	28	606,350	1,180	1,166	4	2	2	13	21	34	23	11	153	221
North	39	24	3	12	129,496	442	593	1	0	1	6	8	9	0	1	53	63
South	36	22	1	13	369,611	589	573	3	2	0	6	11	23	21	5	88	137
Offshore	11	6	2	3	107,243	149	....	0	0	1	1	2	2	2	5	12	21
Michigan	3	3	0	0	4,538	146	158	0	0	0	0	0	3	0	0	46	49
Mississippi	6	4	0	2	35,227	128	135	0	0	0	2	2	4	0	1	50	55
Montana	5	3	0	2	38,582	101	95	0	0	0	1	1	5	0	0	25	30
Nebraska	21	7	0	14	115,781	283	190	1	0	0	10	11	13	0	0	138	151
New Mexico	39	16	19	4	166,307	544	397	3	0	0	2	5	12	0	5	44	61
Northwest	20	1	18	1	67,311	196	99	1	0	0	0	1	1	0	5	13	19
Southeast	19	15	1	3	98,996	348	298	2	0	0	2	4	11	0	0	31	42
North Dakota	3	2	0	1	20,335	68	66	2	0	0	1	3	5	0	0	14	19
Ohio	13	7	2	4	32,243	317	314	0	0	0	0	0	0	0	1	3	4
Oklahoma	184	110	4	†70	619,118	2,672	2,621	1	1	0	19	21	43	10	9	221	283
Pennsylvania-New York	25	11	0	‡14	38,854	242	466	0	0	0	0	0	0	0	1	2	3
Texas	461	280	23	158	1,969,086	6,627	5,980	7	1	3	100	111	251	20	55	1,423	1,749
Southwest (1 & 4)	56	31	5	20	251,525	976	964	1	0	1	16	18	51	5	19	284	359
Gulf Coast (2 & 3)	65	25	11	§29	423,916	837	803	0	0	1	18	19	21	8	21	220	270
East (5 & 6)	13	9	0	4	67,606	337	308	0	0	0	4	4	4	1	4	125	134
North Central (7-B & 9)	195	106	2	87	580,361	2,339	2,073	5	0	0	47	52	112	0	2	543	657
West (7-C & 8)	104	87	2	15	528,196	1,778	1,519	1	0	0	14	15	62	0	6	230	298
Panhandle (10)	28	22	3	3	117,482	360	313	0	1	1	1	3	1	6	3	21	31
Utah	2	0	1	1	6,705	25	19	0	0	0	1	1	1	0	0	17	18
West Virginia	10	1	6	3	25,013	210	180	0	0	0	0	0	0	0	2	3	5
Wyoming	15	12	0	3	78,721	221	241	0	0	0	3	3	5	0	4	64	73
Miscellaneous (S. D.)	1	0	0	1	4,533	50	15	0	0	0	1	1	4	0	0	37	41
Total United States	**1,141**	**625**	**80**	**436**	**4,682,845**	**17,247**	**16,676**	**27**	**4**	**7**	**209**	**247**	**477**	**54**	**109**	**3,146**	**3,786**
Total previous week	1,061	596	75	390	4,440,142	....	....	28	4	4	193	229	450	50	102	2,937	3,539
Total April 23, 1955	1,079	616	81	382	4,582,334	....	....	33	9	14	193	249	473	68	112	2,852	3,505
Cumulative 1956	17,247	9,568	1,133	6,546	71,181,945	....	....	....	....	....	....	....	....	....	....	....	....
Western Canada	22	11	0	11	112,002	772	....	....	....	....	....	....	....	....	....	....	....

Service wells included: *2, †10, ‡11, §1.

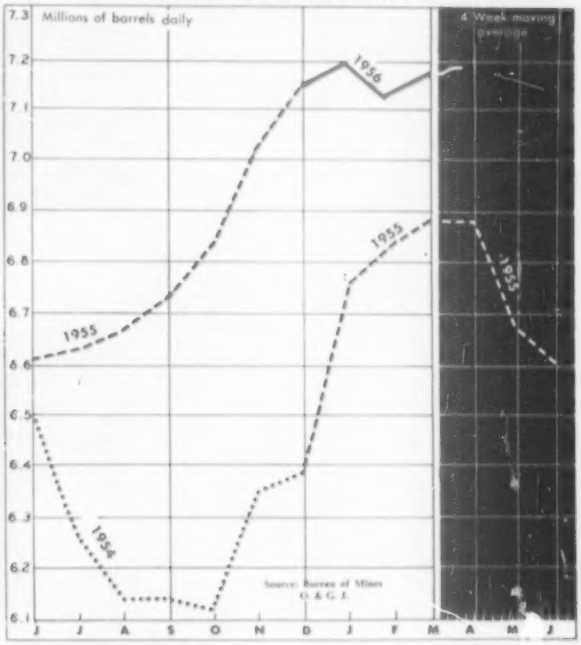
CRUDE IMPORTS



PRODUCT IMPORTS



CRUDE-OIL PRODUCTION

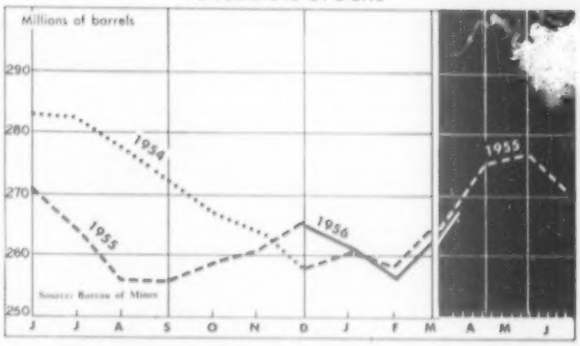


DAILY AVERAGE PRODUCTION FOR WEEK

	April 21			April 14
	Crude oil	Lease condensate	Total	total
Alabama	4,700		4,700	4,900
Arkansas	76,400	500	76,900	72,550
California	965,800		965,800	966,500
Colorado	162,800		162,800	163,500
Eastern	48,100		48,100	48,900
Florida	1,325		1,325	1,325
Illinois	227,300		227,300	228,400
Indiana	32,200		32,200	31,000
Kansas	336,900		336,900	338,400
Kentucky	46,700		46,700	46,600
Louisiana	757,600	69,300	826,900	826,300
North	117,600	2,300	119,900	119,300
South	640,000	67,000	707,000	707,000
Michigan	29,600		29,600	29,900
Mississippi	107,400	4,400	111,800	111,800
Montana	54,600		54,600	57,100
Nebraska	39,100		39,100	40,800
New Mexico	249,050	4,250	253,300	253,400
North Dakota	37,100		37,100	36,800
Oklahoma	594,600		594,600	607,500
Texas	2,982,200	52,825	3,035,025	3,035,025
Dist. 1	54,500	450	54,950	54,950
Dist. 2	151,000	8,500	159,500	159,500
Dist. 3	429,000	25,400	454,500	454,500
Dist. 4	244,000	5,000	249,000	249,000
Dist. 5	45,000	475	45,475	45,475
Dist. 6	125,700	5,900	131,600	131,600
East Texas field	215,000		215,000	215,000
Dist. 7-B	161,000	50	161,050	161,050
Dist. 7-C	189,000	4,400	193,400	193,400
Dist. 8	1,060,000	1,875	1,061,875	1,061,875
Dist. 9	213,000	600	213,600	213,600
Dist. 10	95,000	175	95,175	95,175
Utah	4,900		4,900	4,800
Wyoming	287,300		287,300	288,100
Others	‡200		200	200
Total U. S.	7,045,875	131,275	**7,177,150**	7,193,800
Change from previous week, down			**16,650**	
Canada	†411,600		†411,600	†450,600
Total U. S. production January 1-April 21			797,327,230 bbl.	
Same period last year (crude plus cond.)			*758,845,980 bbl.	

*Includes 12,808,450 bbl. condensate. †Week ended previous Monday. ‡Nevada.

CRUDE-OIL STOCKS



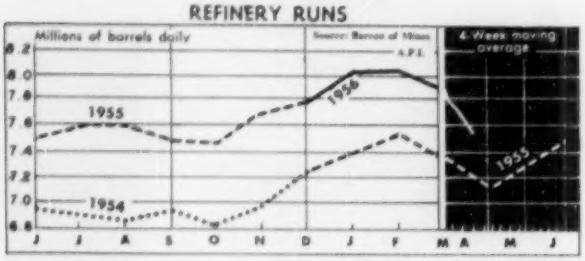
CRUDE-OIL STOCKS BY STATES OF ORIGIN*

(Thousands of barrels)

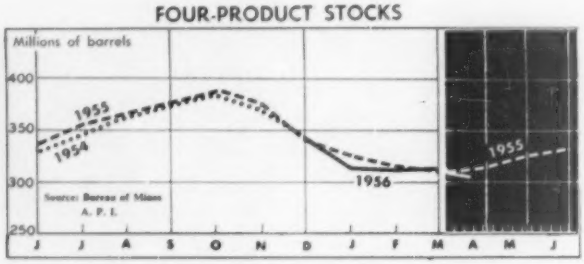
	4-14-56	4-7-56	4-16-55
Pennsylvania Grade	2,678	2,627	2,820
Other Appalachian	2,364	2,225	2,216
Illinois, Indiana, Michigan	10,083	9,940	10,814
Nebraska, North Dakota	2,016	1,792	2,374
Kansas	8,093	7,810	8,591
Oklahoma	24,159	23,779	24,764
Arkansas	2,904	2,915	2,991
Louisiana	16,827	16,446	15,343
North	2,619	2,635	2,500
South	14,208	13,811	12,843
Mississippi	2,998	3,060	2,931
New Mexico	8,284	7,632	8,602
Texas	125,289	123,648	124,502
East Texas proper	8,656	9,205	10,167
West Texas	62,431	61,483	55,339
Texas Gulf	22,102	21,792	24,812
Other Texas	32,100	31,168	34,184
Wyoming	16,108	16,619	14,988
Other Rocky Mountain	5,858	5,771	5,663
California	27,821	27,921	32,527
Foreign	†11,603	11,638	12,299
Total	267,085	263,823	271,425

*Bureau of Mines. †Includes 1,741,000 bbl. in California.

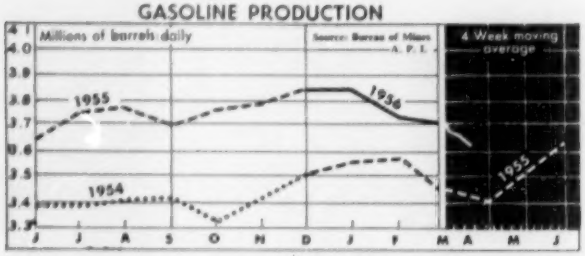
REFINERY RUNS



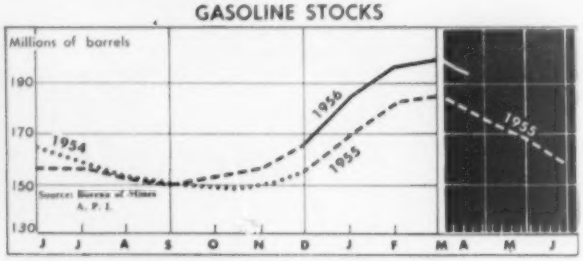
FOUR-PRODUCT STOCKS



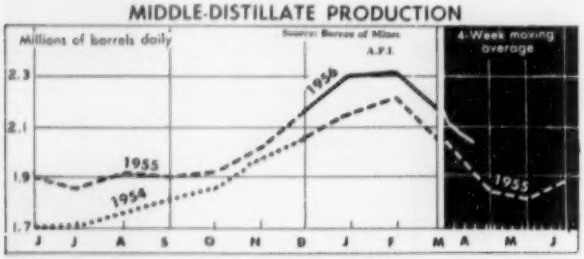
GASOLINE PRODUCTION



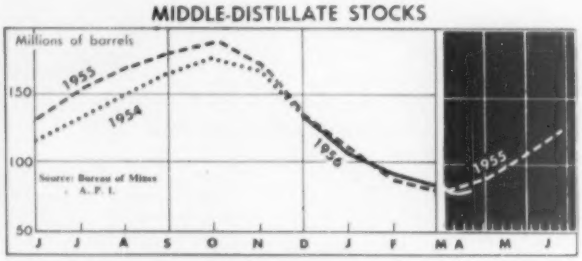
GASOLINE STOCKS



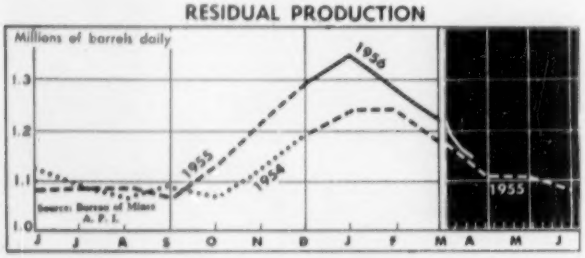
MIDDLE-DISTILLATE PRODUCTION



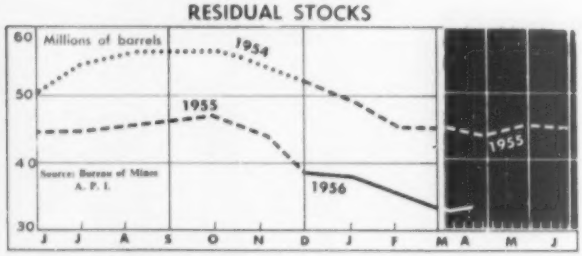
MIDDLE-DISTILLATE STOCKS



RESIDUAL PRODUCTION



RESIDUAL STOCKS



A.P.I. REFINERY REPORT, APRIL 20

(Thousands of barrels)

District—	Daily avg. runs	Daily average production—Gaso.*	Kero.	Dist.	Resid.	Stocks‡—Gaso.†	Kero.	Dist.	Resid.	Bureau of Mines, April 1955—avg. runs Daily	Gaso.* Daily average production	Kero.	Dist.	Resid.
East Coast	1,021	391.4	33.7	271.3	197.2	40,402	7,050	17,538	7,765	996	398.9	26.5	248.7	203.6
Appalachian:														
District 1	105	38.7	2.9	23.3	5.0	4,584	591	1,191	258	100	41.2	3.9	23.9	7.6
District 2	114	55.0	8.7	17.1	13.0	3,069	424	588	266	82	44.7	4.9	13.9	13.2
Ind., Ill., Ky.	1,371	706.9	72.2	276.2	183.7	40,944	3,382	10,430	3,768	1,262	650.3	66.1	240.8	155.3
Okla., Kans., Mo.	656	343.3	17.4	153.4	22.6	21,924	759	6,849	1,062	591	317.2	16.4	136.5	35.9
Inland Texas	248	185.4	11.4	42.4	25.1	7,126	390	1,241	1,373	259	192.2	11.0	46.0	19.2
Texas Gulf Coast	1,864	883.8	92.3	513.3	244.3	26,790	2,568	8,810	5,084	1,793	819.4	112.3	412.6	238.0
La. Gulf Coast	679	308.0	43.1	170.0	62.1	10,338	1,946	4,084	1,501	643	337.0	53.3	160.7	34.7
N. La. and Ark.	69	24.3	3.3	15.3	3.4	4,390	357	1,189	43	86	31.0	7.9	21.7	6.1
Rocky Mountain:														
New Mexico	23	11.7	.....	4.0	2.9	319	5	88	40	21	11.0	0.3	3.5	2.8
Other Rocky Mtn.	214	98.6	1.3	59.1	28.9	7,838	255	2,162	899	226	94.0	3.8	57.7	31.5
California	1,072	467.0	5.7	166.3	380.7	25,209	343	7,756	10,770	1,077	472.4	6.0	168.5	361.7
Apr. 20, 1956	7,436	3,514.1	292.0	1,711.7	1,168.9	192,933	18,070	61,926	32,829	7,136	3,409.3	312.4	1,534.5	1,109.6
Apr. 13, 1956	7,551	3,631.0	295.3	1,738.6	1,168.3	195,059	17,607	60,832	32,788	.....	.....	.....	.....	.....
Apr. 22, 1955	7,099	3,424.9	321.4	1,483.1	1,143.6	179,741	20,429	65,678	44,619	.....	.....	.....	.....	.....

*At refineries including natural blended. †Finished and unfinished. ‡At refineries, bulk terminals, in transit, and in pipelines.

Crude-oil and refinery prices at representative U. S. and foreign points

REFINED-PRODUCT PRICES

Following quotations are for refinery products in cents per gallon moving in interstate shipments on Wednesday each week unless otherwise noted. Crude-oil prices are per barrel at the wells unless otherwise listed.

GASOLINE*

Mid-Continent (Group 3):	
Regular (86 octane)	11.25-11.50
Premium (94 octane)	12.75-13.00
Gulf Coast (cargoes for coastwise or export movement):	
★ Regular (90 octane)	11.25-11.50
Premium (97 octane)	13.00-13.25
New York (barges):	
Regular (89 octane)	12.25
Premium (96 octane)	14.50
California—Los Angeles (rack):	
Regular (84 octane)	12.9-13.15
Premium (93 octane)	14.0-14.25
Caribbean area (cargoes):	
Regular (87 octane)	10.50
Premium (93 octane)	11.50

*Quotations are for octanes shown. Prices usually vary with octane ratings within the regular, premium, and aviation grades.

NATURAL GASOLINE*

Group 3:	
Grade 26-70	4.5
Breckenridge:	
Grade 26-70	4.0

*If 26-70 natural is considered as 100 per cent, prices for lower-vapor-pressure grades increase 2.5 per cent for each unit drop in Reid vapor pressure down to and including 16-lb. Prices for grades below 16-lb. may vary slightly by areas or plants.

KEROSINE AND DISTILLATE

Mid-Continent (Group 3):	
Kerosine 42-44	10.00-10.25
Diesel oil (58 d.i. and above)	9.625-9.875
Distillate No. 1	9.625-9.875
Distillate No. 2	9.00-9.25
Gulf Coast (cargoes):	
★ Kerosine 41-43	9.5
Distillate No. 2	8.75-9.25
New York Harbor (barges):	
Kerosine 41-43	10.85
Distillate No. 2	10.35
Diesel fuel, 48-52 d.i.	10.65
Caribbean area (cargoes):	
Distillate No. 2	8.75

WAX (LB.)

Oklahoma (Group 3):	
132-135 A.m.p. (semi-refined) in tank cars	6.50
New York (export):	
126-130 A.m.p. crude scale (solid in bags or barrels)	7.35

★ Denotes change from previous week.

RESIDUAL FUEL (BBL.)

Mid-Continent (Group 3):	
Residual fuel (max. 1% S)	$2.00-2.10
Gulf Coast (cargoes):	
Bunker C fuel	$2.10
New York Harbor (barges):	
Bunker C fuel	$2.65
Caribbean (cargoes):	
Bunker C at Aruba, N.W.I.	$2.10
California (rack):	
Bunker C fuel, Los Angeles	$2.10-2.20

LUBRICATING OILS

Mid-Continent (Group 3):	
150-160 bright stock, solvent refined, 0-10 p.p., 95 v.i.	24
200 vis. neutral oil, solvent refined, 0-10 p.p., 95 v.i.	20.75
Pennsylvania Grade:	
145-155 vis. at 210, bright stock, 8 color, 25 p.t.	24
200 vis. neutral (180 at 100°), 25 p.t.	21

CRUDE-OIL PRICES

GRAVITY SCHEDULE

	Signal Hill, Calif.	Mid-Cont.*	Gulf Coast Tex.†	West Tex.‡ N.M.	Wyo. (sour)
14-14.9	$2.02	....	....	....	....
15-15.9	2.08	....	....	....	....
16.16.9	2.13	....	....	....	....
17-17.9	2.19	....	....	....	....
18-18.9	2.24	....	....	....	....
19-19.9	2.30	....	....	....	....
20-20.9	2.35	$2.50	....	$2.37	....
21-21.9	2.41	2.52	....	2.39	....
22-22.9	2.47	2.54	....	2.41	....
23-23.9	2.52	2.56	....	2.43	....
24-24.9	2.58	2.58	$2.91	2.45	....
25-25.9	2.64	2.60	2.93	2.47	....
26-26.9	2.69	2.62	2.95	2.49	....
27-27.9	2.76	2.64	2.97	2.51	....
28-28.9	2.83	2.66	2.99	2.53	....
29-29.9	2.91	2.68	3.01	2.55	....
30-30.9	2.97	2.70	3.03	2.57	....
31-31.9	3.04	2.72	3.05	2.59	$2.46
32-32.9	3.12	2.74	3.07	2.61	2.48
33-33.9	3.20	2.76	3.09	2.63	2.50
34-34.9	3.27	2.78	3.11	2.65	2.52
35-35.9	3.34	2.80	3.13	2.67	2.54
36-36.9	3.39	2.82	3.15	2.69	2.56
37-37.9	....	2.84	3.17	2.71	2.58
38-38.9	....	2.86	3.19	2.73	2.60
39-39.9	....	2.88	3.21	2.75	2.62
40 and up	....	2.90	3.23	2.77	2.64

*Includes Oklahoma, Kansas, North Dakota, West Texas (sweet), North Central Texas, North Louisiana, Arkansas, and Wyoming (sweet). †Low-cold-test Gulf Coast. ‡Sour.

Effective dates: California, February 7, 1956; east of California, June 15, 1953; Pennsylvania Grade, March 16, 1956.

FLAT PRICES

Louisiana:	
Cotton Valley (distillate)	$3.00
Cotton Valley (Holloway crude)	2.95
Texas:	
East Texas	2.90
Chapel Hill	2.83
Conroe	3.13
Van	2.73
Pennsylvania Grade:	
Bradford	4.20
Middle District	4.07
Southwest Pennsylvania	3.78
West Virginia	3.66
Buckeye Grade	3.60
Zanesville Grade	3.02
Illinois Basin	3.00
Canada:	
Leduc-Woodbend (flat prices D-2, D-3)	2.60
Redwater (Alta.) D-3	2.49
Smiley-Viking (Sask.)	2.26
Fosterton (Sask.)	1.29
Pembina	2.52

FOREIGN

Venezuela:	
Cumarebo, 48°-48.9°, Tucupido	*3.40
San Joaquin, 41°-41.9°, Puerto La Cruz	*3.04
Oficina, 35°-35.9°, Puerto La Cruz	*2.80
Tia Juana medium, 26.5°-26.9°, Amuay	†2.30
Quiriquire, 16.5°-16.9°, Caripito	†2.21
Lagunillas heavy, flat, Amuay or Las Piedras§	2.05
Bachaquero, 16.5°-16.9°, Amuay or Las Piedras§	†1.90

*Plus or minus 2 cents per barrel for each degree gravity change. †Plus or minus 2.5 cents per barrel for each half-degree gravity change. ‡Plus or minus 3.5 cents per barrel for each half-degree gravity change. §Also available at La Salina at 3.0 cents per barrel less.

Middle East, Persian Gulf (cargoes, f.o.b. lifting port):	
Arabian, 36.0°-36.9°, Ras Tanura	$1.97
Iranian, 34.0°-34.9°, Bandar Mashur	1.91
Iranian, 34.0-34.9°, Abadan	1.86
Iraq, 36.0-36.9°, Fao	1.87
Kuwait, 31.0°-31.9°, Mina-al-Ahmadi	1.72
Qatar, 39.0°-39.9°, Umm Said	2.06
Middle East, E. Mediterranean:	
Arabian, 36.0°-36.9°, Sidon	2.46
Iraq, 36.0°-36.9°, Tripoli, Banias	2.46
Far East (cargoes, f.o.b. Lutong, Sarawak):	
Seria Light, 37°-38°	2.60

TANKER RATES (PER LONG TON)

(Latest reported spot fixtures)

★NWI-U.S.N.H., dirty (USMC+100%)	$5.40
★NWI-U.K., clean (Scale+100%), (65s. 0d.)	9.13
★NWI-U.K., dirty (Scale+45%) (47s. 2d.)	6.63
★Sidon-U.S.N.H., dirty (USMC+10%)	8.58
★P.G.-U.K., dirty (Scale+75%) (94s. 8d.)	13.30

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FOR SALE EQUIPMENT

FAILING 1500 H.D. drill with 4½ x 5 pump, automatic pulldown, mounted on 1951 Ford. Also, Griffin water tank, mounted on 1951 Ford. Write P. O. Box 819, Longmont, Colo., Phone 1333.

FOR SALE: National 50 Drilling Rig Complete, for details, call or write Ralph W. Shebester, Box 337, Pauls Valley, Oklahoma. Telephone 570.

FOR SALE: 1—Oil Well DGE Model 300, Waukesha RLZ motor, Chicago Pneumatic Compressor with 2 cylinders 5 x 13, single stages, testing 1000# unit package—4 Knight Units, with Waukesha engine WAKB, 225 h.p. Worthington compressor 5¼ x 13, with sleeve 6 x 13—1 Homco Unit, Waukesha engine 6WAK, Worthington compressor 5¼ x 13. Complete with scrubbers, automatic dump traps, pressure shut down switches on portable skids. Box J-481, The Oil and Gas Journal, Tulsa, Oklahoma.

COMPLETE CHARCOAL ABSORPTION natural gasoline plant, 20 MMCF capacity with additional purification equipment consisting in part of the following main items: 3 80 hp. boilers; 1 Girbotol purifying tower; Perco treating tower; 3 horizontal activated carbon absorber tanks; 6'6" diameter by 16'6" long, 1" plate; 6 vertical iron-oxide purifier tanks, 4'6" diameter by 13' long, 1" plate; 8 8,000 gal. storage tanks; 1 tank truck loading rack; 1 elevated 8,000 gal. loading-rack supply tank. 4 steel buildings to house above equipment. Plant may be inspected while in operation. Location Cleveland, Ohio. If interested call or write F. C. Durst, Purchasing Agent, The East Ohio Gas Company, 1405 East 6th Street, Cleveland 14, Ohio, Telephone SUperior 1-5100.

Gaso Duplex 4½" x 6" Power Pumps with Chrysler C-36 Engines, skid mounted, immediate delivery. Also Byron Jackson, Carter Centrifugal Units, Westinghouse 20-25-50 KW Generating Units.
H. H. COFFIELD
Attn.: W. H. ORR
Phones: 132—Rockdale, Texas
AT-3427—Houston, Texas

FOR SALE—VERY LARGE LOT OF NEVER USED, FIRST GRADE

Surplus Oil Drilling Equipment

consisting especially of Rock and Drag Bits (Reed, Hughes), Liner Hangers, Cementing equipment, slotted pipe casings API, threading and cutting machines, etc.

UNUSUAL OPPORTUNITY

Give your particulars and write for detailed list to

Bishop International Corp.
1123 BROADWAY
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NEED A PIPE LINE

Have 800 Miles 8" Line Pipe we are taking up through Illinois, Indiana, and Ohio. Will furnish pipe, go in on a deal, or finance.

We are open for any kind of deal.

REDNEB PIPE CO.
P. O. Box 1798 Shreveport, La.
Phone 4-7767—68

FOR SALE EQUIPMENT

CORE DRILLS, SPUDDERS, ROTARIES. New and used equipment. Everything in supplies. Fishing tools rented. Pressey & Son, Pueblo, Colo.

FOR SALE—At Tallant, Oklahoma, three 5'x56' absorbers, 20 trays, 24" spacing 500# WP, peak design each 40,000 MCFD at 350 PSIG; oil rate 100-300 GPM, min. and max. Bought new 1947, taken out of service 1954. Price $8500.00 each, now standing. Full data upon request. Cities Service Oil, Patridge, Bartlesville, Oklahoma.

FOR SALE—Used: 100 Joints, approximately 3,100 feet of 4½" OD Grade "D" Drill Pipe with 5¾" to 6" OD Tool Joints with 4½" FH Threads. This pipe is located in Oklahoma City, priced at $1.50 per foot. Call FALCON SEABOARD DRILLING COMPANY at MElrose 7-2441 in Oklahoma City, or LUther 7-6592 in Tulsa.

PIPE FOR SALE — New — Unused. All seamless grade B, API 5LX, Coated and Wrapped. 200 Feet 12¾" .330 Wall, $4.64 foot. 3200 Feet 8⅝" .277 Wall, $2.14 foot. 1670 Feet 6⅝" .280 Wall, $1.67 foot. 360 Feet 4½" .237 Wall, $1.01 foot. Price includes coating and wrapping, loaded on trucks FOB Montgomery, M. R. Thomason, R.F.D. 6, Box 21, Montgomery, Alabama.

GASOLINE PLANT EQUIPMENT FOR SALE

1—800# 20 MMCF Absorber with Scrubber, etc.

1—Fluor "Counterflo" Induced Draft Cooling Tower Complete.

Vessels, Generators, Pumps, Instruments, Pipe, Valves, and Fittings and Other Equipment necessary in Gasoline Plant Construction. Detailed Inventory Available upon request.

Southern Production Company, Inc.
P. O. Box 670 Phone—EDison 2-6101
FORT WORTH, TEXAS

FOR SALE EQUIPMENT

SALES AND RENTALS. Used cable drilling and fishing tools, casing, production equipment; from the Southwest's largest stock of oil field supplies. Degen Pipe and Supply Co., Tulsa.

FOR SALE—2 truck mounted Bettis steam units. Good condition, equipped for oil field work. Box J-332, The Oil and Gas Journal, Tulsa, Oklahoma.

RECORDING INSTRUMENTS, fair condition, mounted on good truck. Dual power reels and cables. Bargain. Box J-460, The Oil and Gas Journal, Tulsa, Oklahoma.

FOR SALE—At Oil Hill, Kansas: 4—Cooper type 80 twin engine compressor units, with 8½"x20" class A and 15½"x20" class C compressor cylinders. Also, 1—type 80 single DO. with 6½" and 10½" x 20" tandem compressor cylinders. All with 18" x 20" power cylinders. Cities Service Oil, Patridge, Bartlesville, Oklahoma.

FOR SALE—Used: 4,200 Feet of 4" OD Bottleneck Grade "D" Drill Pipe with 5½" to 5¾" OD Tool Joints with H-90 Threads. This pipe is located in Oklahoma City, priced at $1.75 per foot. Call FALCON SEABOARD DRILLING COMPANY at MElrose 7-2441 in Oklahoma City, or LUther 7-6592 in Tulsa.

FOR SALE:

Lignite, Drilling Fluid Emulsifier, finest grade, in bulk only as mined, shipped only in 70 ton hopper type cars, attractively priced. For details contact,

TRANSAMERICAN FACTORS, LTD.
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Los Angeles 14, California.
Telephone VAndike 0180.

FOR SALE

Fairbanks-Morse Diesel Engines
Model 32 E 14 - 2 Cylinder 150 H.P. @ 300 R.P.M. - Almost New - Price Cheap - 2 Available - Write for Full Specifications.

Globe Trading Company
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Phone WOodward 1-8277

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Two 55,000 bbl. Steel Storage Tanks, Steel Cone Roofs. Located at Washington, Kansas.

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TULSA, OKLAHOMA

WRECKING Two Major Oil Refineries

Pure Oil Ref., Charleston, W. Va., and Bay Ref., McPherson, Kans.

HOT OIL PUMPS—Simplex, Duplex, Centrifugal, 100 to 400 GPM, 100 to 1500 PSI—Steam, Electric Motor, Gas & Diesel Drives.
STEAM PUMPS Simplex & Duplex, 22 to 500 GPM, 100 to 1500 PSI.
FRACTIONATOR, 6'-6" x 98'-0", Shell ⅜", Heads ⅞", 40 Trays.
GYRO FRACTIONATOR, 6'-6" x 72'-0", Shell & Heads ⅛", 16 Trays.
CLAY TOWERS, 12'-0" x 30'-6", Shell & Heads 9/16", No Trays.
STABILIZER, 3'-0" x 55'-0", Shell & Heads 11/16", Top Hd. Figd.
NAPHTHA FLASH TOWER, 3'-0" x 37'-6", Shell & Heads ⅜", 7 Trays.
STABILIZER, 3'-0" x 49'-0", Shell & Heads 11/16", 30 Trays.
STABILIZER, 4'-0" x 48'-0", Shell & Heads 5/16", 30 Trays.
FRACTIONATOR, 3'-6" x 56', Shell & Heads ⅜", 22 Trays.
FLASH TOWER, 7'-6" x 32'-6", Shell & Heads ⅛", No Trays.
Other Towers & Pressure Vessels, various sizes & pressures.
Over 100 Heat Exchangers, Condensers, Reboilers & Coolers from 80 to 1500 sq. ft. capacity, Admiralty & Steel Tubes.
Updraft Heaters, Cracking & Reformer Heaters.
Ethyl Lead Blending Unit, 8500 gal. cap. tank, complete.
Compressors, Gas & Steam Driven.
Sharpless Centrifuges, Oil Filter Presses, Chillers, etc.
Electric Motors, Transformers, Instruments.
Steel Storage Tanks, 1000 to 55,000 bbl. capacity.
Tank Plate ¼"—½" and ⅜"—large size sheets.
Used Pipe 2" to 10"—Excellent Condition.
Valves—Fittings—Used Structural Steel.

MANY OTHER ITEMS—WRITE FOR CATALOGUE.

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1546 Guinotte Ave., Kansas City, Mo., Phone HArrison 1-1000.
FIELD OFFICE: Cabin Creek (suburb of Charleston), W. Va. Phone EAST BANK 5611.
ROY CRISP, Mgr., P. O. Box 2321, Charleston, W. Virginia.

FOR SALE EQUIPMENT

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LIQUIDATION!

FORMER LACY REFINERY
BIG SANDY, TEXAS

COMPLETE POLY UNIT, BUILT 1950
UOP RATED 144 BBL./DAY

Complete Perco unit built 1950, Phillips Petroleum rated 1400 bbl./day.
1—Wyatt 30" x 70' Stabilizer 100# 30 tray
20—Brown fintube exchangers, 600# 148 sq. ft. 4-6 chrome.
20—Brown fintube exchangers, 600# 11, 21, 77, 101, 140 sq. ft.
5—Adm. Heat Exchangers, 644, 434, 346 176 sq. ft.
2—Perco reactors 4500 gal., 8' x 12', 347 stls. st. 120#, 1000° F.
1—8' x 96' tower, 40 tray, 135# WP.
1—7' x 30' Propane tank, 250# WP.
1—10' x 50' Crude tower, 18 trays.
1—6' x 34' Vacuum tower, 150#.
1—2' x 50' tower, 24 trays.
3—Welded tanks, 10' x 40', 10' x 30', 5' x 20'.
3—St. Exchs., 920, 850, 480 sq. ft.
9—Oilfield boilers, 125 hp., 275#.
1—Ethyl lead plant.
3—Penn. comp. 8 x 11 x 9, 12 x 11½ x 13, 10 x 6 x 11.
2—Convection furnaces, 20 MIL BTU/hr.
1—Vapor phase cracking furnace.
12—Welded storage tanks, 5000, 2000, 100, 500 Bbl.
8—Hi-vol pumps, 10 x 7 x 18, 10 x 6 x 12, 6 x 4 x 12, 6 x 3 x 8.
30—Duplex piston pumps, all sizes.
1—10' x 30' asphalt still.
6—Steel Bldgs., 20 x 150, 12 x 20, 28 x 40, 20 x 20.
8—GR Fin Tube Exchangers, 101 sq. ft.
1—BS&B Oil & gas separator, 10.7 mcf, 3500 Bbl./day.
Large Selection of Series 15, 30 Steel Valves, 1" to 8".
Approximately 15,000 ft. Schedule 40, 80 pipe, 2" to 8".

EQUIPMENT ELSEWHERE

COMPRESSORS AND PUMPS

2—Worth. LTC-6 830 hp Comps.
3—Clark RA-8 800 hp. Comps.
1—Worth. LTC-3 400 hp. Comp.
1—IR XVG-8 300 hp. Comp.
B-J hot oil pump 3 x 9, 13 st, 325 gpm 4620' hd.
Gould 16" pump 10,500 gpm, 135' hd.

COLUMNS

7'6" x 55' 30 trays 45 lb.
8' x 75' 25 tray 40#
2' x 60' 35 tray 500#
5'6" x 59' 30 tray 200#
2' x 42' 30 tray 250#
13" x 35' 30 tray 500#

HEAT EXCHANGERS AND STILLS

6—Adm. 785, 742, 425 sq. ft.
3—St. 2000, 785 sq. ft.
30—Atmospheric Bentube exch., stls and Adm. 715, 470 sq. ft.
30—304 SS shell & tube condensers 100-1000 sq. ft.
Lab Petro-chem furnace 50,000 BTU/hr.

TANKS & VESSELS

3—10' x 40' hor. wld. tanks
2—8½' x 25' hor tanks 50# WP.
1—10' x 30' hor welded tank

MISCELLANEOUS

800 ft. of 2" 4-6 ch pipe
Large quantity of 410 SS chrome strips and sheets.
Tremendous selection stainless steel and steel valves ½"-6".

Partial List Only

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Or
2401 Third Ave., New York 51, N. Y., CYpress 2-5703

FOR SALE EQUIPMENT

FOR SALE—1 National H-6 single crank pumping unit for 8000 ft. wells. SH-801 beam and post assembly. 72" stroke 40 h.p., peak torque 238,000 inch lbs. First Class Condition. Degen Pipe & Supply, Tulsa.

U-15 DRILLING RIG located in Beaver County, 3 NKU Waukesha Motors, Hydraulic Floor Operated Blowout Preventor, 131' Lee C. Moore Mast, steel mud pits, 7¾ x 16 Gardner-Denver pump, 8000' 4½" Drill Pipe recomplete. Call CEntral 2-6318, Oklahoma City, Oklahoma.

FOR SALE: 3—#71A Rebuilt Speedstars, also, can furnish 55 and 240 Speedstars, 21, 22, 24 Bucyrus and 33 Armstrong. Star Drilling Supply Co., Chanute, Kans., Phone 467.

FOR SALE—Two No. 110 Riise natural gas drilling engines. One has never been used after having been factory re-built at cost of $1,850.00. Selling price, $2,500.00. The other is in good condition, $1,500.00. Humphrey-Stone-McColl Corp., Oil City, Penna., or phone E. M. White, Kittanning, Penna., 43-6177.

FOR SALE: 86' Oilwell Mast, with 6½ Substructure. Telephone: CE 2-6318, Oklahoma City, Okla.

FOR SALE: Oil field trucking business with equipment and permits for Texas and Oklahoma. Grosses $65,000 per year. Located in Wichita Falls, Texas. Address inquiries to Box J-490, The Oil and Gas Journal, Tulsa, Oklahoma.

ALMOST NEW 3000 feet portable rotary complete, trucks, floats, etc., HO 5-3965, #2 Carolane Trail, Houston.

200,000' 2⅜" OD new electric weld upset tubing range 2.8 round thread, hydrostatically tested 3000# PSI. Guaranteed to give same service as seamless tubing 30-60 day delivery. Box J-497, The Oil and Gas Journal, Tulsa, Oklahoma.

FOR SALE: Wilson-Snyder mud pump, 7¼" x 18". Top condition and less than half price. L. T. Peyton Machine Shop, Vernal, Utah. Phone 267.

7 x 10 GASO MUD PUMP and JL 1335 Buda engine. Completely reconditioned. D. S. Campbell, Vinita, Oklahoma.

HEAT TREATER—McKelvy 4' x 20'—25# WP—2" Kimray valves—350,000 BTU—rated 500 Bbls. fluid 500 MCF gas per day—Boswell-Frates Company, 1003 Kennedy Building, Tulsa, Oklahoma.

EMSCO 250 RIG, complete with Emsco double mast. Excellent condition. 4,000-ft. practically new, 4½-in. drill pipe. Rig now running. Bargain. Phone FOrest 8-5886, 421 Meadows Bldg., Dallas, Tex.

MODEL S-32 Special Walker-Neer Spudder, complete with standard equipment, including 6⅝" x 7" x 60' telescoping poles, Model No. 140 GKU-Waukesha Engine, Model 8041 Brown Line Transmission, mounted on Tandem Float, purchased new November, 1955. Equipped with complete tools, Dog House, 49 GMC, FC 452 truck and oilfield platform BC True Trailer, $35,000.00. The Theiss Drilling Company, 740 West Fifth Street, Fort Worth, Texas.

COMPRESSOR BUILDING — Structural steel, 12' x 35' x 120'. Boswell-Frates Company, 1003 Kennedy Building, Tulsa, Oklahoma.

GAS COMPRESSORS—3 Bessemer type 10 twins direct connected units—Boswell-Frates Company, 1003 Kennedy Building, Tulsa, Oklahoma.

WANT EQUIPMENT: Did you find the equipment you wish to purchase in this column? If not, use an "Equipment Wanted" classified advertisement to find it. It is available somewhere and Journal classified advertisements will find it. See box heading for classified rates, or write The Oil and Gas Journal.

BUSINESS OPPORTUNITIES

Would trade Phillips 66 bulk station on jobber contract with cafe and grocery attached (living quarters on same lot). Situated in small county-seat town—has been under same mgt. since 1938. Large trade area. All for fully equipped 45 100' rotary rig in good condition. Contact Wycoff Brothers Oil Company, Oakley, Kansas. Tele. ORange 2-3271.

HELP WANTED

WANT REPRESENTATIVE in South America for specialized line of oilfield production equipment. Commissions are far above average. Send resume giving sales outlets and sales force. Box J-491, The Oil and Gas Journal, Tulsa, Oklahoma.

FOREIGN EMPLOYMENT. List of oil companies and drilling contractors showing where to apply for foreign jobs. OIML Co., Box 2603, Tulsa, Okla. $5.00 cash.

DIVISION MANAGER FOR CONTRACT SEISMIC OPERATION

A top level position for a fully qualified man. Must have experience in **West Texas and New Mexico.**
Based in Midland. Furnish references and resume of experience and background.
Box J-457, The Oil and Gas Journal, Tulsa, Oklahoma.

Plant Equipment Inspectors

Graduate engineers with minimum 5 years' experience in design or inspection of petroleum processing plants and equipment. Major part of experience must have been in inspection work entailing general knowledge of all facilities. Develop inspection methods, supervise and conduct inspections and advise operations on codes and equipment limitations in a major oil installation located in Saudi Arabia.

Write giving full particulars regarding personal history and work experience. Please include your telephone number.

Recruiting Supervisor, Box 99

ARABIAN AMERICAN OIL COMPANY

505 PARK AVENUE
NEW YORK 22, NEW YORK

SAFETY ENGINEER

For modern, independent oil refinery located near St. Paul, Minnesota. He will report directly to the Plant Manager and be responsible for establishing and directing the safety policies and procedures for the operation and maintenance of the refinery, including a sound safety program, the procurement and maintenance of safety and fire fighting equipment, and coordination of plant design and safety.

A Bachelor of Science degree in Mechanical or Civil Engineering or equal with at least three years experience in oil refinery safety work required.

Furnish complete resume of experience and education, including salary requirements. All replies confidential. Write or apply in person:

GREAT NORTHERN OIL COMPANY
Pine Bend Refinery
P. O. Box 3596
St. Paul 1, Minnesota

HELP WANTED

Engineering Services Available

We are in a position to do full time or part time engineering studies and consultations on drilling, producing, and equipment problems for companies active in drilling and producing.

PETROLEUM OVERSEAS CONSULTANTS

5710 H. M. C. ST.,
HOUSTON, TEXAS

PETROLEUM ENGINEERS

For drilling production and equipment on varied types active fields.

EXCELLENT SALARY, ALLOWANCES, OPPORTUNITY OBTAIN ADDITIONAL EXPERIENCE & ADVANCEMENT.

Positions Available Venezuela & Colombia. Graduate Engineers—minimum 2 years exp.

Forward Personal data, college transcript, to:

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SOCONY MOBIL OIL CO., INC.

26 Broadway, New York 4, New York

HELP WANTED

SUBSTANTIAL, integrated, independent, aggressive company with small staff needs Geologist with four to ten years Gulf Coast subsurface experience. Location Houston. Write Box J-489, The Oil and Gas Journal, Tulsa, Oklahoma.

GEOLOGISTS—Two to three years subsurface experience in Midcontinent needed by consulting firm. Apply by letter giving qualifications and salary. Box J-463, The Oil and Gas Journal, Tulsa, Oklahoma.

Petroleum chemist

BEEN LOOKING for a position with lots of day-to-day variety and interest? The petroleum instrumentation section of the Fisher Development Laboratories is the place. Your assignment: to design and promote new items in a leading line of petroleum testing equipment and handle liaison with the ASTM.

Age: 30-40 . . . petroleum lab experience . . . familiarity with ASTM methods and apparatus . . . a flair for instrument design. Employee benefits are excellent; working conditions A-1.

Rush résumé (confidential), salary requirements, instrumentation background, to PAUL FAUPEL, PERSONNEL MGR., FISHER SCIENTIFIC, 711 FORBES ST., PITTSBURGH 19, PENNA.

PETROLEUM ENGINEERS

Graduate Petroleum Engineers with 2 - 6 years' experience wanted by Major Oil Company for work in Mid-Continent and Gulf Coast areas. Openings available for Reservoir and Field Production Engineers. In first reply give resumé of experience, date available, and salary expected.

BOX J-479, THE OIL AND GAS JOURNAL, TULSA, OKLAHOMA.

CHIEF GEOLOGIST

Outstanding opportunity with nationally known mining and chemical manufacturing concern. The Chief Geologist will be a member of a central engineering staff and will be responsible for planning and coordinating a comprehensive program of minerals exploration and development. Will be headquartered in Midwest with reasonable travel throughout U. S. Salary commensurate with background and experience.

Should have experience directing field programs and be familiar with latest exploration techniques. Age 35-50. Undergraduate degree in geology or mining geology preferred. Send detailed resume including salary progression. All replies confidential. Address

Box J-495,
The Oil and Gas Journal,
Tulsa, Oklahoma.

HELP WANTED

EXPLORATION EXECUTIVE—Independent oil producing corporation operating in Mid-Continent field desires experienced man presently employed in middle or top-management exploratory capacity. Please furnish age, education, experience, references and salary required. All replies will be kept confidential. Box J-502, The Oil and Gas Journal, Tulsa, Oklahoma.

CHEMICAL ENGINEERS

For responsible staff positions in New York Office directing the work of groups of experienced engineers doing process evaluation and design, economic studies and related work on refining and crude oil handling facilities, together with supporting power plants and other utilities. Work entails occasional trips of short duration to Europe and Middle East. Chemical Engineering degree plus 5 years' process experience, preferably in petroleum.

Salary commensurate with training and work experience. Liberal benefit program. Write giving full particulars regarding personal history and work experience. Please include telephone number.

Recruiting Supervisor, Box 100

ARABIAN AMERICAN OIL COMPANY

505 Park Ave., New York 22, N. Y.

DESIGN ENGINEERS

You can fill a desirable **permanent** position in McKee's enlarged Refinery, Metals or Industrial Divisions. Our expansion program gives you excellent opportunity for advancement in one of the world's largest engineering firms.

World-wide McKee operation offers you wide choice in the design of Petroleum Refineries, Chemical Plants, Blast Furnaces, Steel Plants, Sintering Plants and Industrial Plants in the following fields:

Piping Layout, Structural Steel, Concrete, Process Heaters, Equipment Specifications, Layout and Process Design. Also Piping and Electrical Draftsmen.

You get top compensation, the security of a life-long pension, paid vacations, benefits of insurance, hospitalization, sick-leave pay and training program.

You'll work with modern equipment in large air-conditioned quarters. Free parking on premises.

Cleveland has attractive residential areas, excellent schools and colleges for you and your family. McKee makes generous transportation and moving allowances.

Write for an interview giving education and experience. No age limitations. All letters kept strictly confidential. Write today to:

EDWARD A. KOLNER

ARTHUR G. McKEE & COMPANY

2300 Chester Avenue
Cleveland 1, Ohio

HELP WANTED

PETROLEUM ENGINEERS

Active independent oil company has vacancies for graduate petroleum engineers with two to five years of practical experience in drilling and production in West, West Central or North Texas. Excellent opportunities for growth and advancement. Replies should furnish complete personal data, education, experience, and starting salary desired.

BOX J-300,
THE OIL AND GAS JOURNAL,
TULSA, OKLAHOMA.

SALES ENGINEER (New Product)

Graduate petroleum, mechanical or chemical engineer with petroleum experience needed for interesting assignment to assist in development and promotion of new equipment for use in petro-chemical industry. Should be familiar with oil processing equipment, design and application. Work will include personal contact with major oil companies. Sales experience helpful.

Mail brief description of qualifications to:

DORR-OLIVER INCORPORATED
2900 Glascock St.
Oakland 1, California.

HELP WANTED

EXPERIENCED EMPLOYEES, for all positions on seismograph field crews, wanted by aggressive, expanding geophysical company. Please give full details of education, experience, salary expected, in first letter. Box J-455, The Oil and Gas Journal, Tulsa, Oklahoma.

WANTED—Responsible Operator to properly complete a test through the Knox Dolomite, on a structural high in Kentucky. Three previous tests had very good shows in this formation. No promoters or brokers. Box 2, Clarendon, Penna.

PETROLEUM ENGINEER

Graduate with 3 to 5 years experience in reservoir and valuation of oil and gas reserves, opening with Mid-Continent Area Bank. In reply give resume of experience and salary expected.

All replies confidential.

Box J-500,
The Oil and Gas Journal,
Tulsa, Oklahoma.

NATURAL GASOLINE PLANT ENGINEER

To conduct field investigations for possible new plant locations (any size) and to supervise contract negotiations, plant design and operations for substantial independent company. Should have broad knowledge of the oil and gas producing areas and successful background of plant operations. Replies should state age, outline personal history and work experience. Replies kept strictly confidential.

BOX J-501, THE OIL AND GAS JOURNAL,
TULSA, OKLAHOMA

WANTED

EXPERIENCED REFINERY PERSONNEL

3 year extendable contract employment in Baghdad, Iraq Government Oil Refineries.

TAX FREE LIBERAL SALARY WITH FURNISHED MODERN HOUSE

We are seeking men to handle the following positions for a combination topping—vis breaking—gas oil cracking—naphtha reforming unit and treating facilities and acid plant.

Process Engineer
Will advise methods of most efficient operation. Chemical Engineering degree or equivalent.

Civil Engineer
Handle layout and construction project assignments. Civil engineering degree or equivalent.

Heavy Duty Mechanic
Maintenance of all heavy duty equipment including diesels and teaching others.

Your application invited if you have recently been working in one of these jobs, have several years experience in it, and can pass a rigid physical examination.

APPLICATIONS ARE ALSO INVITED FOR OTHER JOBS THAT OCCASIONALLY ARE AVAILABLE FOR TECHNICAL AND OPERATING PERSONNEL.

Accepted applicants will be offered contracts embodying tax free liberal salary with furnished modern house including utilities, 1st class air transportation for self and family to Baghdad and return, medical care, accident insurance, and annual 30 day vacation.

Qualified applicants should send complete personal and work history, compensation received, references, and other helpful information you deem pertinent.

Apply by letter to General Refinery Manager,
P. O. Box 1445, Chicago 90, Illinois

HELP WANTED

CHEMIST, Ph.D. Under 35. Interested in organic research. Recent graduates considered. With major oil company in Tulsa. State qualifications and salary expected. Write Employee Relations Department, Post Office Box 381, Tulsa 2, Oklahoma.

Petroleum Geologists

Established Oil Company desires geologists for employment in West Texas area. Must know area and have four to six years of active experience in subsurface mapping and interpretation. Excellent opportunity for advancement. Salary will be commensurate with ability and experience. Reply should state age, education, experience, and salary desired.

BOX J-485,
THE OIL AND GAS JOURNAL,
TULSA, OKLAHOMA.

RESERVOIR ENGINEERS

For reservoir studies, reserve estimation & development work on varied types active fields.

EXCELLENT SALARY, ALLOWANCES, OPPORTUNITY OBTAIN ADDITIONAL EXPERIENCE & ADVANCEMENT.

Positions Available Venezuela & Colombia. Graduate Engineers—minimum 3 years exp.

Forward personal data, college transcripts, to:

C. L. LAUE

SOCONY MOBIL
OIL CO., INC.

26 Broadway, New York 4, New York

Petroleum Engineers
(South America)

Graduate engineers with experience in drilling, production, reservoir and equipment. Working knowledge of Spanish desirable but not essential.

Lubrication Engineers
(West Africa)

Mechanical Engineer's degree and experience in lubrication and petroleum products. Fluent French not essential but working knowledge desirable.

Operations Supervisor
(West Africa)

Experienced all phases construction engineering concerning marketing petroleum products, i.e., appropriations, terminal layout and maintenance. M.E. or C.E. degree desirable but not essential. Working knowledge French essential.

LIBERAL EMPLOYE BENEFIT PLANS
SALARY COMMENSURATE WITH EXPERIENCE
Forward resume of education and experience to

THE TEXAS COMPANY
Foreign Personnel Office
135 East 42nd Street
NEW YORK 17, N. Y.

HELP WANTED

PETROLEUM ENGINEER

The National Iranian Oil Company has vacancy for one experienced Petroleum Engineer to advise management on drilling, production and reservoir engineering problems. Salary commensurate with background and experience. Three years contract. Write giving full details such as age, marital status, education, details of previous experience, last salary, etc., to

Embassy of Iran,
5005 Massachusetts Ave.,
Washington D. C.

OIL FIELD SERVICE ENGINEERS

Mechanical or Petroleum Engineers with some field experience. Men without degrees but with two years rotary or workover rig experience may qualify. High school diploma or equivalent required. Age under 35 preferred. Good pay with excellent fringe benefits. Automobile and expenses.

Contact

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P. O. Box 3048
HOUSTON 1, TEXAS

SITUATIONS WANTED

PETROLEUM ENGINEER: 35 eight years Production & Engineering. Desires to relocate. Box J-493, The Oil and Gas Journal, Tulsa, Oklahoma.

GEOLOGIST, 30, M.S., employed. 3 years Gulf Coast experience with major oil company. Prefer to relocate California. Box J-494, The Oil and Gas Journal, Tulsa, Oklahoma.

GEOPHYSICIST-GEOLOGIST—15 years experience. 5 years supervisory capacity. Desires position with independent or small oil company. Reply Box J-480, The Oil and Gas Journal, Tulsa, Oklahoma.

ENGINEER-LANDMAN-LAWYER wants job with progressive oil company or operator offering opportunity. B.S. & LL.B. degrees, age 35, 10 yrs. experience. Can do engineering or land work, supervise exploration and development or be executive assistant to management. Prefer job developing drilling deals. Box 2702, Midland, Texas.

SUBSURFACE GEOLOGIST—M.S., married, 3½ years domestic experience with major. Desire foreign employment with oil company. Employed. Box J-492, The Oil and Gas Journal, Tulsa, Oklahoma.

SAFETY ENGINEER—Age 38, ten years experience in oil industry, foreign & domestic. Address Apt. 4, 1331 South Peoria, Tulsa, Okla.

GEOPHYSICIST—ten years interpretation and field supervision. Desire position with oil company. Box J-503, The Oil and Gas Journal, Tulsa, Oklahoma.

GEOLOGIST, single, 32, 4½ years geophysical experience, desires position in permanent location. Box J-498, The Oil and Gas Journal, Tulsa, Oklahoma.

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LEGAL

U. S. DEPARTMENT OF THE INTERIOR, Bureau of Land Management, Land Office, Cheyenne, Wyoming. Notice is hereby given that approximately 1557.96 acres of land in six parcels within the known geologic structure of the Poison Spider field, Wyoming, will be offered for oil and gas leasing through competitive bidding to the qualified bidder of the highest cash amount per acre through sealed bids on or before 2:00 P.M., MST, June 7, 1956, when bids will be opened. Details of the lease offering, and how and where to submit bids may be obtained from the Land Office, Cheyenne, Wyoming. Perry T. Williams, Manager.

LEGAL

Sealed Bids will be received until 2:00 P. M. Monday May 7, 1956, and opened at that time at the Pawnee Area Field Office, Pawnee, Oklahoma, for the leasing of allotted lands located in Kay, Noble and Pawnee Counties, Oklahoma, for oil and gas mining purposes. For additional information write or telephone Mr. John L. Johnson, Area Field Representative of the Pawnee Area Field Office (Phone 985).

LEGAL

Sealed bids will be received until 1:00 P.M., Friday, May 11, 1956, and opened at that time at the Shawnee Area Field Office for the leasing of allotted Indian lands located in Cleveland, Pottawatomie, Lincoln, Payne, Oklahoma and Logan counties, Oklahoma, for oil and gas mining purposes. For additional information write or telephone Mr. Robert D. Grover, Area Field Representative, Shawnee, Oklahoma, (Telephone 318).

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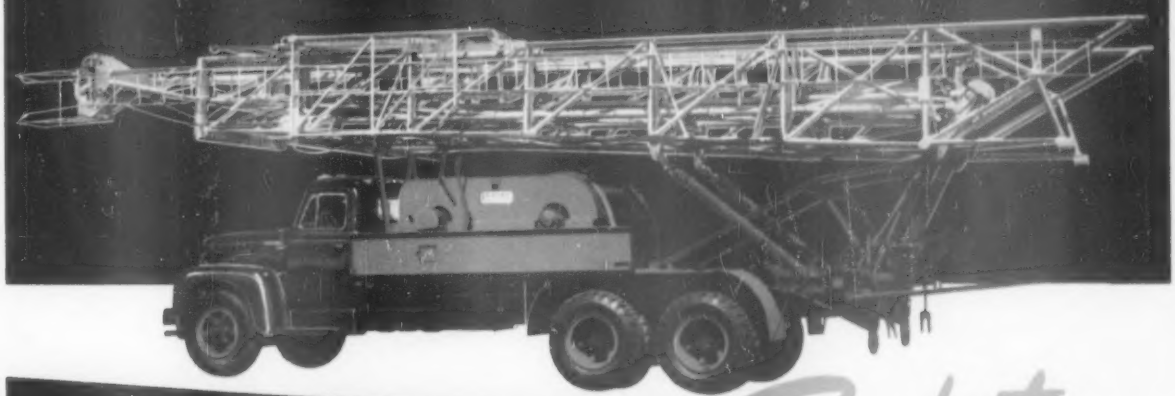

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